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United States Environmental Protection Agency
Region 9

In the Matter of : Iron Mountain Mine Iron Mountain Mines, Inc., T.W. Arman, Rhone-Poulenc Basic Chemicals Co. Respondents Proceeding under Section 106 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986, (42 U.S.C. § 9606)	)	Order No. 93-01

ADMINISTRATIVE ORDER
FOR REMEDIAL DESIGN AND REMEDIAL ACTION

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I. INTRODUCTION AND JURISDICTION

1. This Order is issued to Respondents by the United States Environmental Protection Agency ("EPA") under the authority vested to the President of the United States by section 106(a) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended ("CERCLA"), 42 U.S.C. § 9606(a). This authority was delegated to the Administrator of EPA on January 23, 1987, by Executive Order 12580 (52 Fed. Reg. 2926, January 29, 1987), and was further delegated to EPA Regional Administrators on September 13, 1987 by EPA Delegation No. 14-14B. The Regional Administrator redelegated this authority to the Director, Hazardous Waste Management Division.

2. This Order directs Respondents to design and construct the facilities comprising the remedial actions selected by the

Environmental Protection Agency (EPA) in the September 30, 1992 Record of Decision (ROD 2) for the Iron Mountain Mine site. The design and construction shall meet a standard to allow Respondents to operate and maintain those facilities to achieve the standards of performance specified in ROD 2. ROD 2 selected treatment of the Richmond and Lawson AMD flows in a lime/sulfide High Density Sludge chemical neutralization/ precipitation treatment plant, on-site disposal of treatment plant sludges in the suitably modified Brick Flat Pit, maintenance of the Richmond and Lawson Adits to function as collectors of the AMD, collection and conveyance facilities for the AMD flows, and consolidation and capping of seven waste piles on-site. In the event EPA and Respondents subsequently agree upon the terms of a Consent Decree providing for the completion of the tasks outlined in this Order, the Consent Decree may provide that the terms of that Consent Decree supersede the terms of this Order.

II. FINDINGS OF FACT

3. Iron Mountain Mine ("IMM" or "the Site") is located in the southeastern foothills of the Klamath Mountains, approximately nine miles northwest of the City of Redding. Between the 1860's and 1963, IMM was periodically mined for iron, silver, gold, copper, zinc, and pyrite. The mine area is located on 4,400 acres of property that includes an open pit mine, underground workings, waste rock dumps and tailings piles.

4. IMM averages 70-80 inches of precipitation per year, most of it falling in the form of rain between the months of November and April.

5. IMM is drained by Boulder Creek to the north, and

Slickrock Creek to the south of the mine. Boulder Creek, a perennial stream, receives a portion of its flows from the Lawson and Richmond adits via their mine portals. The Richmond and Lawson adits are the two principal sources of acid mine drainage at Iron Mountain. Slickrock Creek, an intermittent stream, receives discharges from underground seepage and surface flows from the Brick Flat Pit area. A debris slide diverted the original Slickrock Creek drainage and buried adits from which acid mine drainage is emanating.

6. Slickrock Creek and Boulder Creek flow southeastward into Spring Creek, which flows into the Spring Creek Reservoir, created by the construction in 1963 of the Spring Creek Debris Dam, a unit of the Central Valley Project. Releases from Spring Creek drain into Keswick Reservoir, where they mix with releases of clean water from Shasta Dam.

7. The Respondents identified in this paragraph are collectively referred to as "Respondents."

A. T.W. Arman and Iron Mountain Mines, Inc. (IMMI), Respondents are the current owners and operators of Iron Mountain Mines, and have been the owners and operators since approximately December, 1976.

B. Rhone-Poulenc Basic Chemicals Co., Respondent, is the legal successor to Mountain Copper Co., Ltd. and Stauffer Chemical Co. Mountain Copper was the owner and operator of the facility from approximately 1896 to 1967, and continued to own portions of the facility until 1980. Stauffer Chemical Co. owned and operated the facility from approximately 1967 to 1976, and directly and through its wholly owned subsidiary Mountain Copper, continued to own portions of the facility until 1980. During the time that Mountain Copper owned and operated the facility, hazardous substances, including some or all of those described in this section, were disposed of at the Site. This disposal at the facility resulted in releases from the facility into the environment. Releases of hazardous substances into the environment continued during the period Stauffer Chemical Co. owned and operated the facility. Among other actions, both Mountain Copper and Stauffer Chemical Co. owned and operated a copper cementation plant. Effluent from the plant contained copper, cadmium and zinc and was released into surface waters.

8. On September 8, 1983, pursuant to section 105 of CERCLA, 42 U.S.C. § 9605, EPA placed the Site on the National Priorities List, set forth at 40 C.F.R. Part 300, Appendix B.

9. In September, 1983, pursuant to CERCLA and the National Contingency Plan, 40 C.F.R. Part 300, EPA commenced a Remedial Investigation and Feasibility Study ("RI/FS") to study and evaluate potential remedies for the Site. During the course of that investigation, which extended from September 1983 to April 1985, EPA conducted weekly sampling of five major sources at the mine and three locations on Spring Creek, and biweekly sampling at four locations along the Sacramento River for heavy metals; installed flow measurement stations at eight locations, including mine portals and downstream receiving waters; measured precipitation at six gauges throughout the area; reviewed all existing literature on the site; conducted a groundwater

investigation; and conducted two comprehensive surface sampling surveys, involving 76 sampling points, in September 1983 and December 1983.

10. During a dry period in September 1983 and a rainy period in December 1983 EPA conducted the two intensive sampling programs to locate and quantify the sources of heavy metals pollution at the IMM. The Regional Board conducted sampling in April 1983 which reflect usual late winter conditions when the mountain is saturated. The sampling station locations are identified in Figure 2 of the October 1986 Record of Decision (ROD1). The rankings of the heavy metals contribution for copper, cadmium and zinc are shown in Figure 3 of that document.

11. The RI identified five major sources as responsible for approximately seventy two percent of the copper and eighty six percent of the zinc and cadmium being discharged from the site during the sampling period. These sources were: the Richmond Portal, the Lawson portal, Old Mine/No. 8 seep, Big Seep, and the Brick Flat Pit By-Pass. In addition to the five major sources, EPA identified numerous other sources of releases of metals and acid mine drainage at the Site. The studies completed by EPA in 1983 show that the flow of acid mine drainage through tailings piles on the IMM property is also contributing to metals contamination. EPA published notice of the completion of the FS and of the proposed plan for remedial action and provided opportunity for public comment on the proposed remedial action.

12. On October 3, 1986, Assistant Administrator J. Winston Porter approved a Record of Decision (ROD1) for the Site. ROD1

for the Site authorized the following activities: the construction of a cap over the Richmond mineral deposit to reduce infiltration into this source of acid mine drainage; diversion of clean surface water from the Upper Spring Creek watershed before it reaches the portion of the basin affected by IMM; diversion of clean water from the South Fork of Spring Creek; diversion of clean water from Upper Slickrock Creek; enlargement of the Spring Creek Debris Dam; installation of necessary perimeter controls; and conducting a study to better define the use of low density cellular concrete to minimize the formation of acid mine drainage.

13. The hazardous substances released at the Site include copper, cadmium, zinc and sulfuric acid.

14. Historic mining activity at IMM has fractured the mountain increasing access of surface water and rain water and oxygen to the mineralized zones within the mine. The rubblizing of the mine workings has contributed to the formation of acid mine drainage in the mine. Precipitation and surface water infiltrating the mountain forms sulfuric acid in the presence of oxygen due to the oxidation of the pyrite. The sulfuric acid is drained by the mine workings and leaches out copper, cadmium, zinc and other metals. This heavy metal laden acid mine drainage flows out of the mine portals and seeps. Much of the metals bearing acid mine drainage is ultimately channeled by the creeks into the Spring Creek Reservoir. The Bureau of Reclamation periodically releases the stored acid mine drainage impounded behind Spring Creek Debris Dam into Keswick Reservoir. Planned

releases are timed to coincide with the presence of diluting waters from Shasta Dam. On occasion, unplanned spills and excessive waste releases have occurred from Spring Creek Debris Dam, resulting in the release of harmful quantities of metals in the Sacramento River.

15. The Sacramento River is a valuable fisheries resource and is used as a source of drinking water by the City of Redding, with a population of over 50,000. The Central Valley Regional Board adopted water quality standards applicable to the Sacramento River and the tributaries which flow into the Sacramento River from IMM on April 27, 1984. The State Water Resources Control Board and the EPA subsequently approved these standards. The California Fish and Game has identified these levels of metals as protective of all life stages of anadromous salmon and steelhead below Keswick Dam. These recommended levels were adopted by the Regional Board as Basin Plan objectives for the Keswick Dam area and approved by the State Board in August, 1984. EPA approved the objectives under Clean Water Act § 303 on August 7, 1985.

16. The continuous release of metals from IMM and the exceedances of water quality standards caused by the continuing release have contributed to a steady decline in the fisheries population in the Sacramento River. The major fishery resources of the Sacramento River below Keswick Dam include migratory populations of salmon and steelhead and resident populations of wild trout. The adult salmon and steelhead migrate from the ocean to the river where they reproduce. The young remain in the

river through the juvenile life stage or sometime longer in the case of steelhead. Metal laden discharges from the Spring Creek Basin frequently occur at the time of year that the salmonoid life stage most sensitive to metal toxicity is abundant in the river.

17. The estimated monetary value of the chinook salmon and steelhead trout runs produced downstream of the Iron Mountain Mine discharge and upstream from the Red Bluff Diversion dam, once restored, is expected to increase to $72 million annually. The metals from IMM have contributed to fish kills as well as incidents of sublethal toxicity which reduce the overall productivity of the population, including effects such as reduced growth rates, physiological problems, and diminished immune response.

18. In the California Department of Fish and Game's letter requesting EPA assistance with the then impending fish emergency for the winter of 1989-90, the Department stated that "It is well documented that drainage from Iron Mountain Mine contains concentrations of metals and acid toxic to fish and other aquatic life. Fishery resources vulnerable to destruction include four races of chinook salmon, steelhead, and rainbow trout. The chinook salmon include: the winter-run chinook, which has been listed as a State endangered species and a Federal threatened species; spring-run and late fall-run chinook, which are both at low population levels; and the fall-run chinook, which is the stock that supports California's important sport and commercial salmon fishery. Last year the spawning grounds that were

protected from fish kills from Iron Mountain Mine produced over 30 million dollars worth of salmon. Historic fish kills have destroyed fish that are life stages between embryo and adult in as little as a 48-hour exposure period. Fish kills impact the sport and commercial salmon fisheries in future years."

19. In recent years, recurring drought conditions have underscored the importance of water conservation in California. The continued need to rely upon water from Lake Shasta and Keswick Reservoir to mitigate the impacts of acid mine drainage renders significant quantities of water unavailable for beneficial uses, resulting in a significant adverse impact on the human environment. An estimated 64,000 acre feet were released in March, 1989 to prevent a massive fish kill. In the spring of 1992, the United States Bureau of Reclamation released an estimated 95,000 acre feet to dilute the toxic discharges from Iron Mountain Mines which had overflowed the capacity of Spring Creek Debris Dam. During a late winter storm it normally requires a Shasta release 40 to 50 times that of Spring Creek to provide non-toxic conditions for salmon.

20. Near its source, the acid mine drainage contains sulfuric acid in concentrations that could cause serious eye injuries and skin irritation through dermal contact. Although the property owner has posted the property to discourage trespassers who might become exposed, the property is located between two heavily used National Forests and direct exposure can not be ruled out as a possibility.

21. Direct ingestion of contaminated fish from the Sacramento

River does not pose a present health threat. However, without remediation, IMM releases will continue to deposit effluent in sportfishing areas and the concentration of cadmium will continue to be elevated above normal levels, resulting in potential bioaccumulation of cadmium in the livers and kidneys of those who ingest contaminated fish from the river.

22. Iron Mountain Mine has been the subject of numerous response actions over the past several decades. The Regional Water Quality Control Board has initiated numerous actions to require the owners and operators to abate the release of hazardous substances. These actions are described in greater detail in EPA Order No. 89-18.

23. Remedial actions taken by EPA include the construction of a partial cap over Brick Flat Pit (construction started in July, 1988) and construction of a diversion around the slide in Slickrock Creek (construction started in July, 1989). A further remedial action selected in the ROD, construction of a diversion of the Upper Fork of Spring Creek, was implemented by Respondent Rhone-Poulenc acting under a unilateral order, Order No. 90-08.

24. In the winter of 1988-89, EPA operated an emergency treatment plant at the site to reduce the toxicity of the acid mine drainage releases.

25. On August 15, 1989, EPA issued an order requiring Respondents to construct and operate a treatment plant at the site. Among other matters, this order required the construction and operation of a treatment plant capable of removing at least 95% of each of the metals copper, cadmium and zinc from a minimum

of 60 gallons per minute and 95% of the copper from all flows from the Lawson Portal and Old Mine/No. 8. The plant was to remove metals from these sources from December 1, 1989 through March 31, 1990, inclusive, and Respondents were required to submit workplans for implementation in subsequent years. Respondents continued to operate the plant during the winters of 1990-91 and 1991-92. Respondents submitted their proposed operations plan for the winter of 1992-93 on August 18, 1992. That plan proposed treating up to 60 gallons per minute of the acid mine drainage flows from the Lawson Portal and Richmond Portal. The plan provided for treating the most concentrated flows first. Despite a continuing drought in California and the significant overflow of Spring Creek Debris Dam in the spring of 1992, the workplan did not provide for additional controls during the coming winter. Nor did Respondent Rhone-Poulenc's proposal provide an engineering analysis of the practicability of increasing capacity as requested in EPA's letter of July 15, 1992. EPA performed an engineering analysis of the practicability of expanding treatment capacity, and after consideration of this engineering analysis, the Respondent's plan and past experience in controlling the releases, EPA decided to increase the treatment capacity for the winter of 1992-93. The increase was selected in an Action Memorandum signed on September 2, 1992.

26. On September 2, 1992, EPA issued Order 92-26 requiring Respondents to construct necessary modifications and operate a treatment plant to remove at least 99 percent of the copper,

cadmium and zinc from the most concentrated flows of AMD from the Richmond and Lawson portals up to 140 gallons per minute. All AMD flows from these sources in excess of 140 gallons per minute are required to be treated for 95% copper removal. Old Mine/#8 AMD flows are required to be treated for 85% copper removal. The Respondents were required to treat preferentially the most concentrated AMD flows in the lime neutralization plant for 99% zinc, cadmium and copper removal. The Respondents were required to operate the lime neutralization treatment plant from November 1, 1992 until May 30, 1993. Respondents are required to use copper cementation for all AMD flows not treated by lime neutralization treatment year round.

27. ICI Americas, Inc. responding on behalf of Rhone-Poulene Basic Chemicals, notified EPA on September 28, 1992 that they would endeavor to comply with Order 92-26. Design and facilities modifications are currently underway.

28. Operation of the treatment plant at the increased capacity is expected to reduce the volume of acid mine drainage entering Spring Creek Debris Dam, thereby decreasing reliance on the holding capacity of the reservoir.

29. As part of its ongoing efforts to control the acid mine drainage from Iron Mountain, EPA conducted an operable unit feasibility study to develop remedial alternatives for the acid mine drainage releases in the Boulder Creek watershed. EPA's 1992 Remedial Investigation report summarizes the data which shows the concentration, volume and historic patterns of releases of acid mine drainage from the Iron Mountain Mines. On May 20,

1992, EPA published a proposed plan. EPA allowed for sixty days of public comment on the proposed plan. EPA's preferred alternative identified in the proposed plan was the construction and operation of a treatment plant on an interim basis until a permanent remedy could be selected. On September 30, 1992 EPA signed a Record of Decision (ROD2) that selected treatment of the AMD discharges from the Richmond and Lawson adits on an interim basis in a lime/sulfide High Density Sludge (HDS) treatment plant. ROD2 also selected consolidation and capping seven waste piles on site. Treatment plant sludges are to be disposed of on site in the inactive open pit mine, Brick Flat Pit, once suitable modifications are made.

30. Due to the on-going drought conditions in the region, water supply and fishery conditions are critical. EPA has determined that design and construction of the full scale HDS treatment plant must proceed immediately in order to lessen the discharges of hazardous substances and to reduce the current reliance upon partial treatment at the temporary treatment facilities and special releases of valuable water resources from Shasta Lake to protect the fishery. These water resources would otherwise be available in these critical water supply conditions for beneficial uses. Design and construction of the neutralization plant and other critical components must be undertaken immediately in order to have the facility operational by October 30, 1993.

III. CONCLUSIONS OF LAW AND DETERMINATIONS

31. The Iron Mountain Mine Site is a "facility" as defined in section 101(9) of CERCLA, 42 U.S.C. § 9601(9).

32. Respondents are "persons" as defined in section 101(21) of CERCLA, 42 U.S.C. § 9601(21).

33. Respondents are "liable parties" as defined in section 107(a) of CERCLA, 42 U.S.C. § 9607(a), and are subject to this Order under section 106(a) of CERCLA, 42 U.S.C. § 9606(a).

34. The substances listed in paragraph 13 are found at the Site and are "hazardous substances" as defined in section 101(14) of CERCLA, 42 U.S.C. § 9601(14).

35. These hazardous substances have been released, are being released and threaten to continue to be released from the Site into surface waters.

36. The disposal and migration of hazardous substances from the Site are a "release" as defined in section 101(22) of CERCLA, 42 U.S.C. § 9601(22).

37. The potential for future migration of hazardous substances from the Site poses a threat of a "release" as defined in section 101(22) of CERCLA, 42 U.S.C. § 9601(22).

38. The release of the hazardous substances from the facility may present an imminent and substantial endangerment to the public health or welfare or the environment.

39. The contamination and endangerment at this Site constitute an indivisible injury. The actions required by this Order are necessary to protect the public health, welfare, and the environment.

IV. NOTICE TO THE STATE

40. Prior to issuing this Order, EPA notified the State of California Department of Toxic Substances Control, that EPA would be issuing this Order.

V. ORDER

41. Based on the foregoing, Respondents are hereby ordered, jointly and severally, to comply with the following provisions, including but not limited to all attachments to this Order, all documents incorporated by reference into this Order, and all schedules and deadlines in this Order, attached to this Order, or incorporated by reference into this Order:

VI. DEFINITIONS

42. Unless otherwise expressly provided herein, terms used in this Order which are defined in CERCLA or in regulations promulgated under CERCLA shall have the meaning assigned to them in the statute or its implementing regulations. Whenever terms listed below are used in this Order or in the documents attached to this Order or incorporated by reference into this Order, the following definitions shall apply:

a. "CERCLA" shall mean the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. §§ 9601 et seq.

b. "Day" shall mean a calendar day unless expressly stated to be a working day. "Working day" shall mean a day other than a Saturday, Sunday, or Federal holiday. In computing any period of time under this Order, where the last day would fall on a Saturday, Sunday, or Federal holiday, the period shall run until the end of the next working day.

c. "DTSC" shall mean the California Department of Toxic Substances Control.

d. "EPA" shall mean the United States Environmental Protection Agency.

e. "National Contingency Plan" or "NCP" shall mean the National Contingency Plan promulgated pursuant to Section 105 of CERCLA, 42 U.S.C. § 9605, codified at 40 C.F.R. Part 300, including any amendments thereto.

f. "Operation and Maintenance" or "O&M" shall mean all activities required under the Operation and Maintenance Plan developed by Respondent(s) pursuant to this Order and the Statement of Work, and approved by EPA.

g. "Paragraph" shall mean a portion of this Order identified by an arabic numeral.

h. "Performance Standards" shall mean those cleanup standards, standards of control, and other substantive requirements, criteria or limitations, identified in the ROD2, this Order, and the attached Statement of Work, that the Work required by this Order must attain and maintain.

i. "The first Record of Decision" or "ROD1" shall mean the EPA Record of Decision relating to the Site, signed October 3, 1986, by Assistant Administrator J. Winston Porter, and all attachments thereto.

j. The "second Record of Decision", the "Boulder Creek OU ROD," or "ROD2." shall mean the EPA Record of Decision relating to the Site, signed September 30, 1992, and all attachments thereto.

k. Response Costs" shall mean all costs, including direct costs, indirect costs, and accrued interest incurred by the United States and the State of California to perform or support response actions at the Site. Response costs include but are not limited to the costs of overseeing the Work, such as the costs of reviewing or developing plans, reports and other items pursuant to this Order and costs associated with verifying the Work.

l. "RWQCB" shall mean the Regional Water Quality Control Board, Central Valley Region.

m. "Statement of Work" or "SOW" shall mean the statement of work for implementation of the Remedial Design, Remedial Action, and Operation and Maintenance at the Site, as set forth in Attachment A to this Order. Attachments B through J modify and clarify attachment A. The Statement of Work and all attachments are incorporated into this Order and are an enforceable part of this Order.

n. "Section" shall mean a portion of this Order identified by a roman numeral and includes one or more paragraphs.

o. "Site" shall mean the Iron Mountain Mine Superfund site, encompassing the approximately 4400 acres of mine property located in Shasta County, California, as described in the ROD2, and the areas downgradient and downstream where hazardous substances released from the mines have come to be located.

p. "State" shall mean the State of California.

q. "United States" shall mean the United States of America.

r. "Work" shall mean all activities Respondents are required to perform under this Order, including design, construction, Operation and Maintenance, and any activities required to be undertaken pursuant to Sections VII through XXIV, and XXVII of this Order.

VII. NOTICE OF INTENT TO COMPLY

43. Respondents shall provide, on the effective date of this Order, written notice to EPA's Remedial Project Manager (RPM) stating whether they will comply with the terms of this Order. If Respondents do not unequivocally commit to perform the work as provided by this Order, they shall be deemed to have violated this Order and to have failed or refused to comply with this Order. Respondent's written notice shall describe, using facts that exist on or prior to the effective date of this Order, any "sufficient cause" defenses asserted by Respondents under sections 106(b) and 107(c)(3) of CERCLA. The absence of a response by EPA to the notice required by this paragraph shall not be deemed to be acceptance of Respondent's assertions.

VIII. PARTIES BOUND

44. This Order shall apply to and be binding upon each Respondent identified in paragraph 7, their directors, officers, employees, agents, successors, and assigns. Respondents are jointly and severally responsible for carrying out all activities required by this Order. No change in the ownership, corporate status, or other control of any Respondents shall alter any of the Respondents' responsibilities under this Order.

45. Respondents shall provide a copy of this Order to any prospective owners or successors before a controlling interest in

Respondent's assets, property rights, or stock are transferred to the prospective owner or successor. Respondents shall provide a copy of this Order to each contractor, sub-contractor, laboratory, or consultant retained to perform any Work under this Order, within five days after the effective date of this Order or on the date such services are retained, whichever date occurs later. Respondent(s) shall also provide a copy of this Order to each person representing any Respondents with respect to the Site or the Work and shall condition all contracts and subcontracts entered into hereunder upon performance of the Work in conformity with the terms of this Order. With regard to the activities undertaken pursuant to this Order, each contractor and subcontractor shall be deemed to be related by contract to the Respondents within the meaning of section 107(b)(3) of CERCLA, 42 U.S.C. § 9607(b)(3). Notwithstanding the terms of any contract, Respondents are responsible for compliance with this Order and for ensuring that their contractors, subcontractors and agents comply with this Order, and perform any Work in accordance with this Order.

46. Within five (5) days after the effective date of this Order each Respondent that owns real property comprising all or part of the Site shall record a copy or copies of this Order in the appropriate governmental office where land ownership and transfer records are filed or recorded. Respondents shall, within 15 days after the effective date of this Order, send notice of such recording and indexing to EPA.

47. Not later than sixty (60) days prior to any transfer of any

real property interest in any property included within the Site, Respondents shall submit a true and correct copy of the transfer documents to EPA, and shall identify the transferee by name, principal business address and effective date of the transfer.

IX. WORK TO BE PERFORMED

48. **Public information and meetings.** Respondents shall cooperate with EPA in providing information regarding the Work to the public. As requested by EPA, Respondents shall participate in the preparation of such information for distribution to the public and in public meetings which may be held or sponsored by EPA to explain activities at or relating to the Site.

49. **State participation.** Respondents shall submit copies of documents submitted pursuant to this section for EPA review to DTSC at the same time the documents are submitted to EPA. The State shall have the right to participate in all meetings required by this section.

50. **Enforceability.** All documents approved by EPA under this section shall become enforceable provisions of this Order and non-compliance with any approved document will be subject to penalties in the same manner as any other violation of this Order.

PROJECT MANAGER

51. All aspects of the Work to be performed by Respondents pursuant to this Order shall be under the direction and supervision of a qualified project manager the selection of whom shall be subject to approval by EPA. Within 5 days after the effective date of this Order, Respondents shall notify EPA in

writing of the name and qualifications of the project manager, including primary support entities and staff, proposed to be used in carrying out Work under this Order. If at any time Respondents propose to use a different project manager, Respondents shall notify EPA and shall obtain approval from EPA before the new project manager performs any Work under this Order.

52. EPA will review Respondents' selection of a project manager according to the terms of this paragraph and Section XIV of this Order. If EPA disapproves of the selection of the project manager, Respondents shall submit to EPA within 30 days after receipt of EPA's disapproval of the project manager previously selected, a list of project managers, including primary support entities and staff, that would be acceptable to Respondents. EPA will thereafter provide written notice to Respondents of the names of the project managers that are acceptable to EPA. Respondents may then select any approved project manager from that list and shall notify EPA of the name of the project manager selected within twenty-one (21) days of EPA's designation of approved project managers.

SITE HEALTH AND SAFETY PLAN

53. **Remedial design field activities.** Within thirty (30) days after approval of Respondent(s)' project manager, Respondents shall prepare and submit to EPA for review, a Site Health and Safety Plan for field design activities. The Site Health and Safety Plan shall conform to the applicable Occupational Safety and Health Administration and EPA requirements, including but not

limited to 54 Fed. Reg. 9294.

54. **Remedial action field activities.** Respondent(s) shall submit to EPA for review, not later than 14 days after EPA approves all deliverables required as part of the Final Design, a Health and Safety Plan for field activities. The Health and Safety Plan for field activities shall conform to applicable Occupational Safety and Health Administration and EPA requirements, including but not limited to the regulations at 54 Fed. Reg. 9294.

55. Respondents shall design and construct the remedial actions selected in ROD2 in accordance with the Attachments to this Order, which are incorporated by reference to this Order and as outlined in this Order.

PRELIMINARY PROJECT DELIVERY ANALYSIS (PPDA)

56. Within twenty-one (21) days after the effective date of this Order, Respondents shall submit for EPA review and approval a Preliminary Project Delivery Analysis (PPDA) in detailed written form and as described in Attachment A, Task II A and B to this Order. The Respondents shall develop the PPDA, in accordance with the Statement of Work (SOW) in Attachment A and the detailed technical attachments B through J to this Order. The PPDA shall be fully consistent with that SOW and technical attachments.

57. The PPDA shall include a step-by-step plan for completing the remedial design for the remedy described in ROD2 and for attaining and maintaining all requirements, including Performance Standards, identified in ROD2. The PPDA must describe in detail the tasks and deliverables Respondent(s) will complete during the

remedial design phase, and a schedule for completing the tasks and deliverables in the PPDA. The major tasks and deliverables shall include, but not be limited to, the following:

(1) a preliminary design (as detailed in Attachment A, Task II.C)(to be discussed in a preliminary design meeting);

(2) a pre-final design (as detailed in Attachment A, Task III)(to be discussed in a pre-final design meeting);

(3) expedited preliminary prefinal and final design for time critical components (as detailed in Attachment A, Task II.D);

(4) a final design, including a Draft Operation and Maintenance Plan (as detailed in Attachment A, Task III);

(5) a design Sampling and Analysis Plan (SAP)(optional)(as detailed in Attachment A, Task II.B);

(6) a Contingency Plan (as detailed in Attachment A, Task III.B);

(7) a Construction Quality Assurance Plan (CQAP) (as detailed in Attachment A, Task III.B);

(8) a Construction Management Plan (CMP)(as detailed in Attachment A, Task III.B);

(9) treatability studies (optional) (as detailed in Attachment A, Task II.B); and

(10) a plan for gathering additional data or information (optional) (as detailed in Attachment A, Task II).

58. The PPDA shall also provide for implementing the Remedial Action, pursuant to the EPA approved Final Design (and EPA approved Final Designs for expedited remedial action or time

critcial components).

59. The PPDA for the remedial action phase shall be developed in accordance with ROD2, the Statement of Work in Attachment A, and all of the detailed technical attachments. At a minimum, the PPDA shall provide for sufficient completion of the remedial action pursuant to the Final Design to enable the full operation of the treatment plant in accordance with the performance standards of ROD2 by October 31, 1993. The PPDA shall include methodologies, plans and schedules for completion of at least the following:

(1) pre-construction conference (Attachment A, Task III.C);

(2) selection of the remedial action contractor (paragraph 78);

(3) implementation of the CQAP (Attachment A, Task III.B.2);

(4) development and submission of the monitoring plan (detailed in Attachment A, Task III.B.3);

(5) identification of and satisfactory compliance with applicable permitting requirements (Attachment A, Task II.C.4);

(6) development and submission of the draft final and final Operation and Maintenance Plan (O & M Plan)(the draft final O & M Plan to be submitted at 50% of construction complete and the final O & M Plan at the time Respondents notify EPA that construction is complete)(Attachment A, Task IV);

(7) pre-final construction inspection (Attachment A, Task

III.D);

(8) final construction inspection (Attachment A, Task III.E);

(9) implementation of the Contingency Plan (Attachment A, Task III.B.3);

(10) development and submission of the Performance Standards assessment plan (detailed in Attachment A, Task V);

(11) Final Construction Report (Attachment A, Task III.F); and

(12) Remedial Action Report (Attachment A, Task III.G).

The PPDA shall also include a schedule for implementing all remedial action tasks identified in the Statement of Work and shall identify the initial formulation of Respondent's Remedial Action Project Team(including the Supervising Contractor).

60. **Identification of Time-critical Components.** The Respondents shall identify and detail in the PPDA -- and in the DFPDA and the final PDA -- time critical components for procurement and construction that require initiation prior to formal review of the prefinal plans and specifications. The Respondents shall develop in detail the design, design review, construction and scheduling requirements for these time critical components. The PDA shall provide for EPA review and approval of the preliminary, pre-final and final designs for each of these time critical components. (Examples of such time critical components may include initial site preparation, county and on-site road improvements, improvement of Flat Creek Bridge, equipment procurement and utility construction.) The final design

submittals for these time critical components shall include all plans specified in Paragraph 62 of this Order, and as detailed in Attachment A, Task II.D..

61. **Implementation of Time-critical Components.** The Respondents shall implement the design and construction tasks for these time critical project components pursuant to the PPDA, DFPDA and the EPA approved PDA and schedule to enable procurement and construction in accordance with the necessary expedited schedule.

62. **Workplanning Meeting.** Respondents shall attend a workplanning meeting with EPA within seven (7) days after the submittal of the PPDA to EPA. The Respondents shall present and discuss the PPDA including preliminary design concepts, design criteria, deliverables, and schedules for design and construction. The Respondents shall document by letter within seven (7) days following the workplanning meeting the preliminary design concepts and criteria and shall provide a listing of all deliverables and a revised schedule for design and construction in accordance with agreements reached at the work planning meeting.

FINAL DRAFT PROJECT DELIVERY ANALYSIS (FDPDA)
AND PRELIMINARY DESIGN

63. Ninety-eight (98) days after the effective date of this Order, the Respondents shall submit to EPA for EPA review and approval copies of the Final Draft PDA (FDPDA) and preliminary design deliverables The preliminary design deliverables are identified in Attachment A, Task II.C.

64. The FDPDA required pursuant to this Order shall provide for

implementation of the remedial action pursuant to the EPA approved Final Design and the EPA approved designs for expedited remedial action components.

65. **Preliminary design meeting.** After submittal of the FDPDA and within one hundred and five (105) days after the effective date of this Order, the Respondents shall attend a preliminary design meeting to discuss:

(1) preliminary design plans and specifications,

(2) preliminary design concepts and deliverables, and

(3) the Final Draft PDA (FDPDA), including the critical path schedule providing for final design and construction.

66. **Major equipment components.** At or prior to the meeting, the Respondents shall present a listing of major equipment components and selected manufacturers, equipment specifications, and the schedule for major equipment procurement, manufacture, and delivery to the site. Respondents shall arrange for a representative of the Respondent's chosen major equipment manufacturer to attend the preliminary design meeting.

67. **Documentation of meeting.** EPA will document all agreements and action items from the preliminary design review meeting in a letter within seven (7) days from the date of the meeting. In the event EPA and Respondents do not agree on all items, EPA will notify Respondents of its decision on such items in this letter. Respondents shall incorporate all agreements, action items, and EPA decisions in subsequent deliverables.

FINAL PROJECT DELIVERY ANALYSIS

68. Respondents shall submit a Final PDA within seven (7) days of receipt of EPA's letter documenting agreements on action items from the preliminary design review meeting. The Final PDA shall include all necessary modifications identified at the preliminary design review meeting and EPA's letter documenting the design review meeting.

69. The Final PDA shall identify deliverables (e.g. plans, specifications, or equivalent) subject to EPA approval and shall include a schedule which provides for a minimum of fourteen (14) days for EPA review and comment on each deliverable, and an opportunity for a review meeting with EPA for any formal prefinal design. The review meeting will allow Respondents and EPA to discuss final modifications (fix-up items) and for EPA to identify such fix-up items.

70. The Final PDA shall include the schedule for submittal of the prefinal plans, submittals, and specifications, and for holding a prefinal design meeting. The pre-final design submittals are detailed in Attachment A, Task III.

71. **Pre-final design meeting.** The Final PDA shall provide for a minimum EPA review of 14 days for the prefinal plans and specifications prior to the pre-final design meeting.

72. The Respondents shall document agreements and fix-up items identified in the pre-final design meeting in a letter to be submitted to EPA for review and approval within seven (7) days after the meeting.

73. Upon EPA approval, the Respondents shall implement all design tasks developed pursuant to the prefinal design review and

meeting, the final PDA and schedule to advance the design to the prefinal stage. Unless otherwise directed by EPA's RPM (either orally or in writing), Respondents shall not perform further work at the site prior to EPA's written approval of the PDA and schedule. Respondents shall provide written confirmation of any oral direction authorizing further work prior to EPA's written approval of the PDA and schedule.

74. Upon EPA aprroval, Respondents shall implement the remedial action pursuant to the EPA approved Final Design and the EPA approved designs for expedited remedial action components.

FINAL DESIGN

75. The Respondents shall submit a Final Design to EPA for review and approval in accordance with the PDA and schedule. The Final Design submittal shall include the following:

(1) final plans and specifications;

(2) a Draft Operation and Maintenance Plan;

(3) the Construction Quality Assurance Plan (CQAP);

(4) the Construction Management Plan;

(5) the Sampling and Analysis Plan (directed at measuring progress toward meeting performance standards); and

(6) a Health and Safety/Contingency Plan.

The CQAP shall describe the approach to quality assurance and shall specify a quality assurance official (QA Official), independent of the construction contractor, to conduct a quality assurance program during the construction phase of the project.

IMPLEMENTATION OF FINAL DESIGN

76. Pre-construction conference. Prior to construction of the

remedial action or any time-critical components, Respondents shall meet with the State and EPA in a pre-construction conference to discuss and resolve any outstanding issues with respect to construction.

77. The Respondents shall implement all remedial action tasks of the EPA approved PDA according to the approved schedule. Unless otherwise directed by EPA, Respondents shall not commence remedial action at the site prior to EPA approval of the PDA and the Final Design (or EPA approval of the PDA and the final design for a component remedial action that must be expedited for early procurement or construction).

78. **Construction contractor.** If Respondent(s) seeks to retain a construction contractor to assist in the performance of the Remedial Action, then Respondent(s) shall submit a copy of the contractor solicitation documents to EPA and DTSC not later than five (5) days after publishing the solicitation documents. Respondent(s) shall notify EPA promptly in writing of the name, title, and qualifications of any construction contractor proposed to be used in carrying out work under this Order upon selection of the contractor. If at any time Respondent(s) proposes to change the construction contractor, Respondent(s) shall notify EPA and shall obtain approval from EPA as provided in this paragraph, before the new construction contractor performs any work under this Order. If EPA disapproves of the selection of any contractor as the construction contractor, Respondent(s) shall submit a list of contractors that would be acceptable to them to EPA within thirty (30) days after receipt of EPA's

disapproval of the contractor previously selected.

79. **Pre-certification inspection.** Within thirty (30) days after Respondent(s) conclude that the Remedial Action has been fully performed, Respondent(s) shall so notify EPA and shall schedule and conduct a pre-certification inspection to be attended by Respondent(s) and EPA. Respondents shall submit the final O & M Plan at the time of this notification. The pre-certification inspection shall be followed by a written report submitted within thirty (30) days of the inspection by a registered professional engineer and Respondent(s') Project Coordinator certifying that the Remedial Action has been completed in full satisfaction of the requirements of this Order. If, after completion of the pre-certification inspection and receipt and review of the written report, EPA determines that the Remedial Action or any portion thereof has not been completed in accordance with this Order, EPA shall notify Respondent(s) in writing of the activities that must be undertaken to complete the Remedial Action and shall set forth in the notice a schedule for performance of such activities. Respondent(s) shall perform all activities described in the notice in accordance with the specifications and schedules established therein. If EPA concludes, following the initial or any subsequent certification of completion by Respondent(s) that the Remedial Action has been fully performed in accordance with this Order, EPA may notify Respondent(s) that the Remedial Action has been fully performed. EPA's notification shall be based on present knowledge and Respondent's certification to EPA, and shall not limit EPA's right to perform periodic reviews pursuant

to section 121(c) of CERCLA, 42 U.S.C. § 9621(c), or to take or require any action that in the judgment of EPA is appropriate at the Site, in accordance with 42 U.S.C. §§ 9604, 9606, or 9607.

80. **Off-site shipment.** Respondent(s) shall, prior to any off-site shipment of hazardous substances from the Site to an out-of-state waste management facility, provide written notification to the appropriate state environmental official in the receiving state and to EPA's RPM of such shipment of hazardous substances. However, the notification of shipments shall not apply to any off-Site shipments when the total volume of all shipments from the Site to the State will not exceed ten (10) cubic yards.

a. The notification shall be in writing, and shall include the following information, where available:

(1) the name and location of the facility to which the hazardous substances are to be shipped;

(2) the type and quantity of the hazardous substances to be shipped;

(3) the expected schedule for the shipment of the hazardous substances; and

(4) the method of transportation.

Respondent(s) shall notify the receiving state of major changes in the shipment plan, such as a decision to ship the hazardous substances to another facility within the same state, or to a facility in another state.

b. Respondent(s) shall determine the identity of the receiving facility and state following the award of the contract for Remedial Action construction. Respondent(s) shall provide all relevant information, including information under the categories noted in paragraph (a) above, on the off-Site shipments as soon as practicable after the award of the contract and before the hazardous substances are actually shipped.

PERFORMANCE STANDARDS

81. The Work performed by Respondent(s) pursuant to this Order shall, at a minimum, achieve the Performance Standards specified in the Record of Decision and meet the requirements specified in Attachment A, the Statement of Work and the technical attachments B though J.

82. Notwithstanding any action by EPA, Respondent(s) remain fully responsible for achievement of the Performance Standards in the Record of Decision and Statement of Work. Nothing in this Order, or in EPA's approval of the Statement of Work, or in the Project Delivery Analysis, or approval of any other submission, shall be deemed to constitute a warranty or representation of any kind by EPA that full performance of the Remedial Design or Remedial Action will achieve the Performance Standards set forth in ROD2. Respondent's compliance with such approved documents does not foreclose EPA from seeking additional work to achieve the applicable performance standards.

X. FAILURE TO ATTAIN PERFORMANCE STANDARDS

83. In the event that EPA determines that additional response activities are necessary to meet applicable Performance Standards, EPA may notify Respondents that additional response actions are necessary.

84. Unless otherwise stated by EPA, within thirty (30) days of receipt of notice from EPA that additional response activities are necessary to meet any applicable Performance Standards, Respondents shall submit for approval by EPA a work plan for the additional response activities. The plan shall conform to the applicable requirements of sections IX, XVI, and XVII of this Order. Upon EPA's approval of the plan pursuant to Section XIV, Respondents shall implement the plan for additional response activities in accordance with the provisions and schedule contained therein.

XI. EPA PERIODIC REVIEW

85. Under section 121(c) of CERCLA, 42 U.S.C. § 9621(c), and any applicable regulations, EPA may review the Site to assure that the Work performed pursuant to this Order adequately protects human health and the environment. Until such time as EPA certifies completion of the Work, Respondents shall conduct the requisite studies, investigations, or other response actions as determined necessary by EPA in order to permit EPA to conduct the review under section 121(c) of CERCLA. As a result of any review performed under this paragraph, Respondents may be required to perform additional Work or to modify Work previously performed.

XII. ADDITIONAL RESPONSE ACTIONS

86. EPA may determine that in addition to the Work identified in this Order and attachments to this Order, additional response activities may be necessary to protect human health and the environment. If EPA determines that additional response activities are necessary, EPA may require Respondents to submit a

work plan for additional response activities. EPA may also require Respondents to modify any plan, design, or other deliverable required by this Order, including any approved modifications.

87. Not later than thirty (30) days after receiving EPA's notice that additional response activities are required pursuant to this Section, Respondents shall submit a work plan for the response activities to EPA for review and approval. Upon approval by EPA, the work plan is incorporated into this Order as a requirement of this Order and shall be an enforceable part of this Order. Upon approval of the work plan by EPA, Respondents shall implement the work plan according to the standards, specifications, and schedule in the approved work plan. Respondents shall notify EPA of their intent to perform such additional response activities within seven (7) days after receipt of EPA's request for additional response activities.

XIII. ENDANGERMENT AND EMERGENCY RESPONSE

88. In the event of any action or occurrence during the performance of the Work which causes or threatens to cause a release of a hazardous substance or which may present an immediate threat to public health or welfare or the environment, Respondents shall immediately take all appropriate action to prevent, abate, or minimize the threat, and shall immediately notify EPA's Remedial Project Manager (RPM). If the RPM is unavailable Respondents shall notify the EPA Emergency Response Unit, Region 9. Respondents shall take such action in consultation with EPA's RPM and in accordance with all applicable

provisions of this Order, including but not limited to the Health and Safety Plan and the Contingency Plan. In the event that Respondents fail to take appropriate response action as required by this Section, and EPA takes that action instead, Respondents shall reimburse EPA for all costs of the response action not inconsistent with the NCP. Respondents shall pay the response costs in the manner described in Section XXIV of this Order, within thirty (30) days of Respondent's receipt of demand for payment and a Regionally-prepared cost summary, which includes all direct and indirect costs incurred by EPA and the state and their contractors of the costs incurred.

89. Nothing in the preceding paragraph shall be deemed to limit any authority of the United States to take, direct, or order all appropriate action to protect human health and the environment or to prevent, abate, or minimize an actual or threatened release of hazardous substances on, at, or from the Site.

XIV. EPA REVIEW OF SUBMISSIONS

90. After review of any deliverable, plan, report or other item which is required to be submitted for review and approval pursuant to this Order, EPA may: (a) approve the submission; (b) approve the submission with modifications; (c) disapprove the submission and direct Respondents to re-submit the document after incorporating EPA's comments; or (d) disapprove the submission and assume responsibility for performing all or any part of the response action. As used in this Order, the terms "approval by EPA," "EPA approval," or a similar term means the action described in paragraphs (a) or (b) of this paragraph.

91. In the event of approval or approval with modifications by EPA, Respondents shall proceed to take any action required by the plan, report, or other item, as approved or modified by EPA.

92. Upon receipt of a notice of disapproval or a request for a modification, Respondents shall, within twenty-one (21) days or such longer time as specified by EPA in its notice of disapproval or request for modification, correct the deficiencies and resubmit the plan, report, or other item for approval. Notwithstanding the notice of disapproval, or approval with modifications, Respondents shall proceed, at the direction of EPA, to take any action required by any non-deficient portion of the submission.

93. If any submission is not approved by EPA, Respondents shall be deemed to be in violation of this Order.

XV. PROGRESS REPORTS

94. In addition to the other deliverables set forth in this Order, Respondents shall provide monthly progress reports to EPA with respect to actions and activities undertaken pursuant to this Order. The progress reports shall be submitted on or before the 7th day of each month for activities pursuant to this Order undertaken in the previous month following the effective date of this Order. Respondent's obligation to submit progress reports continues until EPA gives Respondents written notice that such progress reports are no longer necessary. At a minimum these progress reports shall provide the information specified in the Statement of Work.

XVI. QUALITY ASSURANCE, SAMPLING AND DATA ANALYSIS

95. Respondents shall use the quality assurance, quality control, and chain of custody procedures described in the "EPA NEIC Policies and Procedures Manual," May 1978, revised May 1986, EPA-330/9-78-001-R, EPA's "Guidelines and Specifications for Preparing Quality Assurance Program Documentation," June 1, 1987, EPA's "Data Quality Objective Guidance," (EPA/540/G87/003 and 004) and any amendments to these documents, while conducting all sample collection and analysis activities required herein by any plan. To provide quality assurance and maintain quality control, Respondents shall:

a. Use only laboratories which have a documented Quality Assurance Program that complies with EPA guidance document QAMS-005/80.

b. Ensure that the laboratory used by the Respondents for analyses, performs according to a method or methods deemed satisfactory to EPA and submits all protocols to be used for analyses to EPA at least 14 days before beginning analysis.

c. Ensure that EPA personnel and EPA's authorized representatives are allowed access to the laboratory and personnel utilized by the Respondents for analyses.

96. Respondents shall notify EPA not less than fourteen (14) days in advance of any sample collection activity not otherwise specified in the Statement of Work. At the request of EPA, Respondents shall allow split or duplicate samples to be taken by EPA or its authorized representatives, of any samples collected by Respondents with regard to the Site or pursuant to the implementation of this Order. In addition, EPA shall have the right to take any additional samples that EPA deems necessary.

XVII. COMPLIANCE WITH APPLICABLE LAWS

97. All activities by Respondents pursuant to this Order shall be performed in accordance with the requirements of all Federal and state laws and regulations. EPA has determined that the activities contemplated by this Order are consistent with the National Contingency Plan (NCP).

98. Except as provided in section 121(e) of CERCLA and the NCP, no permit shall be required for any portion of the Work conducted entirely on-Site. Where any portion of the Work requires a Federal or state permit or approval, Respondents shall submit timely applications and take all other actions necessary to obtain and to comply with all such permits or approvals.

99. This Order is not, and shall not be construed to be, a permit issued pursuant to any Federal or state statute or regulation.

100. All materials removed from the Site shall be disposed of or treated at a facility approved by EPA's RPM and in accordance with section 121(d)(3) of CERCLA, 42 U.S.C. § 9621(d)(3); with the U.S. EPA "Revised Off-Site policy," OSWER Directive 9834.11, November 13, 1987; and with all other applicable Federal, state, and local requirements.

XVIII. REMEDIAL PROJECT MANAGER

101. All communications, whether written or oral, from Respondents to EPA shall be directed to EPA's Remedial Project Manager. Respondents shall submit to EPA three copies of all documents, including plans, reports, and other correspondence, which are developed pursuant to this Order, and shall send these

documents by certified mail or overnight mail to EPA's Remedial Project Manager:

Rick Sugarek
United States Environmental Protection Agency
Region 9 - H-6-2
75 Hawthorne Street
San Francisco, California 94105
(415) 744-2226

Copies to be provided DTSC under this Order shall be sent to:

Duncan Austin
Department of Toxic Substances Control
10151 Croyden Way
Sacramento, California 95827
(916) 255-3706

102. EPA has the unreviewable right to change its Remedial Project Manager. If EPA changes its Remedial Project Manager, EPA will inform Respondents in writing of the name, address, and telephone number of the new Remedial Project Manager.

103. EPA's RPM shall have the authority lawfully vested in a Remedial Project Manager (RPM) and On-Scene Coordinator (OSC) by the National Contingency Plan, 40 C.F.R. Part 300. EPA's RPM shall have authority, consistent with the National Contingency Plan, to halt any work required by this Order, and to take any necessary response action.

104. Within ten (10) days after the effective date of this Order, Respondents shall designate a Project Coordinator and shall submit the name, address, and telephone number of the Project Coordinator to EPA for review and approval. Respondents' Project Coordinator shall be responsible for overseeing Respondents' implementation of this Order. If Respondents wish to change their Project Coordinator, Respondents shall provide written notice to EPA, five (5) days prior to changing the Project

Coordinator, of the name and qualifications of the new Project Coordinator. Respondents selection of a Project Coordinator shall be subject to EPA approval.

XX. SITE ACCESS AND DATA/DOCUMENT AVAILABILITY

105. Respondents shall allow EPA and its authorized representatives and contractors to enter and freely move about all property at the Site and off-Site areas subject to or affected by the work under this Order or where documents required to be prepared or maintained by this Order are located, for the purposes of inspecting conditions, activities, the results of activities, records, operating logs, and contracts related to the Site or Respondents and its representatives or contractors pursuant to this Order; reviewing the progress of the Respondents in carrying out the terms of this Order; conducting tests as EPA or its authorized representatives or contractors deem necessary; using a camera, sound recording device or other documentary type equipment; and verifying the data submitted to EPA by Respondents. Respondents shall allow EPA and its authorized representatives to enter the Site, to inspect and copy all records, files, photographs, documents, sampling and monitoring data, and other writings related to work undertaken in carrying out this Order. Nothing herein shall be interpreted as limiting or affecting EPA's right of entry or inspection authority under Federal law.

106. Respondents may assert a claim of business confidentiality covering part or all of the information submitted to EPA pursuant to the terms of this Order under 40 C.F.R. § 2.203, provided such

claim is not inconsistent with section 104(e)(7) of CERCLA, 42 U.S.C. § 9604(e)(7) or other provisions of law. This claim shall be asserted in the manner described by 40 C.F.R. § 2.203(b) and substantiated by Respondents at the time the claim is made. Information determined to be confidential by EPA will be given the protection specified in 40 C.F.R. Part 2. If no such claim accompanies the information when it is submitted to EPA, it may be made available to the public by EPA or the state without further notice to the Respondents. Respondents shall not assert confidentiality claims with respect to any data related to Site conditions, sampling, or monitoring.

107. Respondents shall maintain for the period during which this Order is in effect, an index of documents that Respondents claims contain confidential business information. The index shall contain, for each document, the date, author, addressee, and subject of the document. Upon written request from EPA, Respondents shall submit a copy of the index to EPA.

XXI. RECORD PRESERVATION

108. Respondents shall provide to EPA upon request, copies of all documents and information within their possession and/or control or that of their contractors or agents relating to activities at the Site or to the implementation of this Order, including but not limited to sampling, analysis, chain of custody records, manifests, trucking logs, receipts, reports, sample traffic routing, correspondence, or other documents or information related to the Work. Respondents shall also make available to EPA for purposes of investigation, information gathering, or

testimony, their employees, agents, or representatives with knowledge of relevant facts concerning the performance of the Work.

109. Until ten (10) years after EPA provides notice that Respondents have completed the tasks required by this Order, each Respondent shall preserve and retain all records and documents in its possession or control, including the documents in the possession or control of their contractors and agents on and after the effective date of this Order that relate in any manner to the Site. At the conclusion of this document retention period, Respondents shall notify the United States at least ninety (90) calendar days prior to the destruction of any such records or documents, and upon request by the United States, Respondents shall deliver any such records or documents to EPA.

110. Until ten (10) years after EPA provides notice that Respondents have completed the tasks required by this Order, Respondents shall preserve, and shall instruct their contractors and agents to preserve, all documents, records, and information of whatever kind, nature or description relating to the performance of the Work. Upon the conclusion of this document retention period, Respondents shall notify the United States at least ninety (90) days prior to the destruction of any such records, documents or information, and, upon request of the United States, Respondents shall deliver all such documents, records and information to EPA.

111. Within 30 days after the effective date of this Order, Respondents shall submit a written certification to EPA's RPM

that they have not altered, mutilated, discarded, destroyed or otherwise disposed of any records, documents or other information relating to their potential liability with regard to the Site since notification of potential liability by the United States or the State or the filing of suit against it regarding the Site. Respondents shall not dispose of any such documents without prior approval by EPA. Respondents shall, upon EPA's request and at no cost to EPA, deliver the documents or copies of the documents to EPA.

XXII. DELAY IN PERFORMANCE

112. Any delay in performance of this Order that, in EPA's judgment, is not properly justified by Respondents under the terms of this paragraph shall be considered a violation of this Order. Any delay in performance of this Order shall not affect Respondents obligations to fully perform all obligations under the terms and conditions of this Order.

113. Respondents shall notify EPA of any delay or anticipated delay in performing any requirement of this Order. Such notification shall be made by telephone to EPA's RPM within forty eight (48) hours after Respondents first knew or should have known that a delay might occur. Respondents shall adopt all reasonable measures to avoid or minimize any such delay. Within five (5) business days after notifying EPA by telephone, Respondents shall provide written notification fully describing the nature of the delay, any justification for delay, any reason why Respondents should not be held strictly accountable for failing to comply with any relevant requirements of this Order,

the measures planned and taken to minimize the delay, and a schedule for implementing the measures that will be taken to mitigate the effect of the delay. Increased costs or expenses associated with implementation of the activities called for in this Order is not a justification for any delay in performance.

XXIII. ASSURANCE OF ABILITY TO COMPLETE WORK

114. Respondents shall demonstrate their ability to complete the Work required by this Order and to pay all claims that arise from the performance of the Work by obtaining and presenting to EPA within thirty (30) days after approval of the Work Plan, one of the following: (1) a performance bond; (2) a letter of credit; (3) a guarantee by a third party; or (4) internal financial information to allow EPA to determine that Respondents has (have) sufficient assets available to perform the Work. Respondents shall demonstrate financial assurance in an amount no less than the estimate of cost for the activities required by the Statement of Work. If Respondents seeks to demonstrate ability to complete the remedial action by means of internal financial information, or by guarantee of a third party, they shall re-submit such information annually, on the anniversary of the effective date of this Order. If EPA determines that such financial information is inadequate, Respondents shall, within thirty (30) days after receipt of EPA's notice of determination, obtain and present to EPA for approval one of the other three forms of financial assurance listed above.

115. At least seven (7) days prior to commencing any work at the Site pursuant to this Order, Respondents shall submit to EPA a

certification that Respondents or their contractors and subcontractors have adequate insurance coverage or have indemnification for liabilities for injuries or damages to persons or property which may result from the activities to be conducted by or on behalf of Respondents pursuant to this Order. Respondents shall ensure that such insurance or indemnification is maintained for the duration of the Work required by this Order.

XXIV. REIMBURSEMENT OF RESPONSE COSTS

116. Respondents shall reimburse EPA, upon written demand, for all response costs incurred by the United States in overseeing Respondent's implementation of the requirements of this Order or in performing any response action which Respondents fails to perform in compliance with this Order. EPA may submit to Respondents on a periodic basis an accounting of all response costs incurred by the United States with respect to this Order. EPA's certified Agency Financial Management System summary data (SPUR Reports), or such other summary as certified by EPA, shall serve as basis for payment demands.

117. Respondents shall, within thirty (30) days of receipt of each EPA accounting, remit a certified or cashier's check for the amount of those costs. Interest shall accrue from the later of the date that payment of a specified amount is demanded in writing or the date of the expenditure. The interest rate is the rate established by the Department of the Treasury pursuant to 31 U.S.C. § 3717 and 4 C.F.R. § 102.13.

118. Checks shall be made payable to the Hazardous Substances

Superfund and shall include the name of the Site, the Site identification number, the account number and the title of this Order. Checks shall be forwarded to:

U.S. Environmental Protection Agency
Superfund Accounting
P.O. Box 360863M
Pittsburgh, PA 15251

119. Respondents shall send copies of each transmittal letter and check to the EPA's RPM.

XXV. UNITED STATES NOT LIABLE

120. The United States, by issuance of this Order, assumes no liability for any injuries or damages to persons or property resulting from acts or omissions by Respondents, or its (their) directors, officers, employees, agents, representatives, successors, assigns, contractors, or consultants in carrying out any action or activity pursuant to this Order. Neither EPA nor the United States may be deemed to be a party to any contract entered into by Respondents or its (their) directors, officers, employees, agents, successors, assigns, contractors, or consultants in carrying out any action or activity pursuant to this Order.

XXVI. ENFORCEMENT AND RESERVATIONS

121. EPA reserves the right to bring an action against Respondents under section 107 of CERCLA, 42 U.S.C. § 9607, for recovery of any response costs incurred by the United States related to this Order and not reimbursed by Respondents. This reservation shall include but not be limited to past costs, direct costs, indirect costs, the costs of oversight, the costs

of compiling the cost documentation to support oversight cost demand, as well as accrued interest as provided in section 107(a) of CERCLA.

122. Notwithstanding any other provision of this Order, at any time during the response action, EPA may perform its own studies, complete the response action (or any portion of the response action) as provided in CERCLA and the NCP, and seek reimbursement from Respondents for its costs, or seek any other appropriate relief.

123. Nothing in this Order shall preclude EPA from taking any additional enforcement actions, including modification of this Order or issuance of additional Orders, and/or additional remedial or removal actions as EPA may deem necessary, or from requiring Respondents in the future to perform additional activities pursuant to CERCLA, 42 U.S.C. § 9606(a), et seq., or any other applicable law. Respondents shall be liable under CERCLA section 107(a), 42 U.S.C. § 9607(a), for the costs of any such additional actions.

124. Notwithstanding any provision of this Order, the United States hereby retains all of its information gathering, inspection and enforcement authorities and rights under CERCLA, RCRA and any other applicable statutes or regulations.

125. Respondents shall be subject to civil penalties under section 106(b) of CERCLA, 42 U.S.C. § 9606(b), of not more than $25,000 for each day in which Respondents willfully violates, or fails or refuses to comply with this Order without sufficient cause. In addition, failure to properly provide response action

under this Order, or any portion hereof, without sufficient cause, may result in liability under section 107(c)(3) of CERCLA, 42 U.S.C. § 9607(c)(3), for punitive damages in an amount at least equal to, and not more than three times the amount of any costs incurred by the Fund as a result of such failure to take proper action.

126. Nothing in this Order shall constitute or be construed as a release from any claim, cause of action or demand in law or equity against any person for any liability it may have arising out of or relating in any way to the Site.

127. If a court issues an order that invalidates any provision of this Order or finds that Respondents has sufficient cause not to comply with one or more provisions of this Order, Respondents shall remain bound to comply with all provisions of this Order not invalidated by the court's order.

XXVII. ADMINISTRATIVE RECORD

128. Upon request by EPA, Respondents must submit to EPA all documents related to the selection of the response action for possible inclusion in the administrative record file.

XXVIII. EFFECTIVE DATE AND COMPUTATION OF TIME

129. This Order shall be effective 7 days after the Order is signed by the Director, Hazardous Waste Management Division. All times for performance of ordered activities shall be calculated from this effective date.

XXIX. OPPORTUNITY TO CONFER

130. Respondents may, within seven (7) days after the date this Order is signed, request a conference with EPA's Director,

Hazardous Waste Management Division, to discuss this Order. If requested, the conference shall occur no later than seven (7) days after the request is made and shall be held at EPA Region 9, 75 Hawthorne Street, San Francisco, CA. The Director may designate an alternate to meet with Respondents in the event of a schedule conflict.

131. The purpose and scope of the conference shall be limited to issues involving the implementation of the response actions required by this Order and the extent to which Respondents intend to comply with this Order. This conference is not an evidentiary hearing, and does not constitute a proceeding to challenge this Order. It does not give Respondents a right to seek review of this Order, or to seek resolution of potential liability, and no official stenographic record of the conference will be made. At any conference held pursuant to Respondent's request, Respondents may appear in person or by an attorney or other representative.

132. Requests for a conference must be by telephone followed by written confirmation mailed that day to

Rick Sugarek
United States Environmental Protection Agency
Region 9
75 Hawthorne Street
San Francisco, California 94105
(415) 744-2226

133. The scheduling of a conference (or failure to do so) under this Section does not delay or otherwise affect Respondents' obligations to notify EPA under Section VII of their intent to comply with the terms of this Order, under the terms of Section VII.

XXX. EFFECT ON PREVIOUS ORDERS

134. Nothing in this order shall be construed to alter the terms of or to excuse any non-compliance with any previous order issued to Respondents, including Order Nos. 89-18, 90-08 and 91-18, and 92-26.

So Ordered, this 3rd day of November, 1992.

BY: ______________________
Jeff Zelikson
Director, Hazardous Waste Management Division
U.S. Environmental Protection Agency, Region 9

<u>Attachments</u>
Attachment A - Statement of Work
Attachment B - Activity Descriptions for Project Design and Construction and Preliminary Schedule
Attachment C - Technical Memorandum TP.01a: Wet Landfill Concept for Sludge Disposal
Attachment D - Technical Memorandum TP.01b: Dry Landfill Concept for Sludge Disposal
Attachment E - Technical Memorandum TP.01c: Brick Flat Pit Discharge System
Attachment F - Technical Memorandum TP.02: Quality and Quantity Estimates for Portal AMD Flows
Attachment G - Technical Memorandum TP.03: Treatment Plant Design Criteria
Attachment H - Technical Memorandum TP.04: Materials of Construction
Attachment I - Technical Memorandum TP.05: Civil Site and Access Road Design Criteria
Attachment J - Technical Memorandum TP.06: Monitoring and Reporting Requirements
Record of Decision, dated September 30, 1992

ATTACHMENT A

STATEMENT OF WORK

BOULDER CREEK OPERABLE UNIT

IRON MOUNTAIN MINE

SHASTA COUNTY, CALIFORNIA

REMEDIAL DESIGN AND REMEDIAL ACTION

TABLE OF CONTENTS

I. INTRODUCTION

The following Statement of Work (SOW) outlines the work to be performed by Respondents to implement the remedial actions selected in EPA's September 30, 1992 Record of Decision (ROD2) for the Iron Mountain Mine Superfund site in Shasta County, California ("IMM","the Site"). The definitions proposed in Section VI of EPA Unilateral Order #93-01 shall also apply to this SOW.

This SOW provides additional information on procedures and tasks for performing the ROD2 remedial actions at IMM pursuant to Unilateral Order #93-01, Section IX. Work conducted shall achieve the clean-up levels and performance standards set forth in ROD2. This document does not provide complete task specific engineering, or geologic guidance. Attachments B through J provide some task specific engineering, and geologic analysis for consideration and use in the development of the plans and specifications, and design submittals required. The requirements of work to be performed shall be further developed and detailed in the Project Delivery Analysis (PDA), design submittals, and plans and specifications to be submitted by respondents pursuant to the Unilateral Order and this SOW.

II. OVERVIEW OF THE REMEDY

On September 30, 1992 EPA selected an interim remedial action for sources of hazardous substance releases at the Iron Mountain Mine site, which is located in Shasta County, California, near the City of Redding. This EPA Record of Decision (ROD2) provided a remedy for sources in the Boulder Creek Operable Unit. The selected interim remedial action is to collect and treat the acid mine drainage (AMD) discharges from the Richmond and Lawson portals and to excavate, consolidate onsite, and cap seven waste piles that have been identified as actively eroding and discharging hazardous substances to Boulder Creek. The selected interim remedial action was chosen in accordance with CERCLA, as amended by SARA, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based upon the administrative record for the site.

Heavy metal-laden acid mine drainage is released from several and possibly all of the inactive mine workings at Iron Mountain and from numerous waste piles on the mine property. The acid mine drainage discharges to surface waters (which include Boulder, Slickrock, and Spring Creeks, the Spring Creek Reservoir, Keswick Reservoir, and the Sacramento River) causing severe environmental impacts and posing a potential threat to human health. The Sacremento River is a major fishery and source of drinking water for Redding. The National Oceanic and Atmospheric Administration (NOAA) has identified the affected area as the most important salmon habitat in the State. Under the Clean Water Act § 304(l) inventory of impaired water bodies and the point sources affecting the water bodies, EPA identified Iron Mountain Mine as the largest such discharger of toxic metals in the United States.

EPA has identified control of acid mine drainage sources in the Boulder Creek Operable Unit as a major step in the ultimate control of discharges of contamination from the Iron Mountain Mine. Two of the sources in the Boulder Creek drainage, the Richmond and Lawson portals, are the two largest sources of AMD at the site. Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in ROD2 may present an imminent and substantial endangerment to public health, welfare, or the environment.

The remedy selected in ROD2 addresses the principal threat posed by the contaminant releases from sources within the Boulder Creek watershed at Iron Mountain through collecting and treating the Richmond and Lawson portal discharges. The excavation, consolidation, and capping of seven identified waste piles will further reduce hazardous substance discharges that contribute to the site problems.

III. REMEDY COMPONENTS

A. SOURCE CONTROL

A.1. Respondents shall consolidate and cap seven waste piles on-site. The seven waste piles (identified as WR-2, WR-12, WR-13, WR-14, WR-17, WR-18, and WR-19 in the Boulder Creek OUFS) shall be consolidated on-site and capped in accordance with applicable California requirements for disposal of mining wastes, promulgated under Water Code § 13172.

The Respondents shall gather additional data, as approved by EPA, to verify the extent to which the waste piles should be removed, consolidated and capped. At a minimum, all mining wastes in these waste piles which qualify as group A or Group B wastes under 23 C.C.R. § 2571(b) shall be removed for disposal in accordance with California mining waste requirements.

A.2 The Respondents shall maintain the Richmond and Lawson adits to allow the mine workings to continue to function as effective collectors of AMD.

A.3 The Respondents shall design, construct and operate collection structures, pipelines and equalization facilities to provide for the delivery of all AMD flows from the Richmond and Lawson adits to the treatment facility for treatment.

The collection and conveyance systems shall provide for delivery of all base flows, sustained elevated flows, and peak AMD discharges from the Richmond and Lawson adits.

A.4 The Respondents shall design, construct and operate treatment facilities to perform chemical neutralization/precipitation treatment of the Richmond and Lawson AMD flows. The treatment shall meet the effluent limitations of 40 C.F.R §§ 440.102(a) and 440.103(a). (Except for pH and TSS levels for discharges into Boulder Creek or Slickrock Creek). EPA has determined that these standards are relevant and appropriate in this application. Discharge to Flat Creek must meet the pH and TSS levels which EPA has determined are relevant and appropriate.

The Treatment plant shall provide equalization capacity, treatment capacity or combination of both to ensure that all of the AMD flows are treated in compliance with the performance standards.

EPA has selected lime/sulfide High Density Sludge (HDS) as the treatment process. The HDS plant shall be designed to provide capacity to treat sustained elevated flows from the Richmond and Lawson portals.

A.5 The Respondents shall dispose of treatment residuals on-site in the inactive open pit mine, Brick Flat Pit. Brick Flat Pit shall be modified to comply with the applicable requirements of the Toxic Pits Control Act, Health and Safety Code § 25208, et seq., and California requirements for disposal of mining wastes promulgated under Water Code § 13172.

B. PERFORMANCE STANDARDS

B.1 Compliance Testing

The Respondents shall perform compliance testing to ensure that all performance Standards are met. The treatment plant discharges, treatment residuals, the waste piles, and soils underlying the waste piles remaining after cleanup shall be tested in accordance with the Performance Standard Verification Plan developed pursuant to Task V of this SOW.

B.2 Treatability Studies

As a part of the Remedial Design in accordance with the Project Delivery Analysis (PDA), Respondents may perform a treatability study to ensure that the HDS treatment plant will attain all Performance Standards. The study results and operating conditions shall be used to verify whether the detailed design meets ROD2 requirements. The results of the treatability study will be evaluated by EPA to determine whether the proposed treatment will attain the Performance

Standards set forth in ROD2, the Unilateral Order and this Statement of Work. The Treatability Study Final Report shall be submitted to EPA within seven (7) days following completion of the study. The specific details relating to the treatability study workplan, the treatability study and the final report are addressed in Task II.A and B of this SOW.

IV. PLANNING AND DELIVERABLES

The specific work to be performed shall be documented by Respondents in a Project Delivery Analysis (PDA) for design and construction. The Respondents shall develop an Operation and Maintenance Plan (O&M Plan) for operation of the facilities to meet the objectives of EPA's ROD2 performance standards. The PDA shall include a critical path schedule for design and construction and provide a schedule for submittal and review of deliverables including but not limited to all reports, plans and specifications outlined and described in this SOW and Unilateral Order #93-01.

Respondents shall submit a technical memorandum documenting any need for additional data along with the proposed Data Quality Objectives (DQO's) whenever such requirements are identified. Respondents are responsible for fulfilling additional data and analysis needs identified by EPA during the remedial design/remedial action (RD/RA) process consistent with the general scope and objectives of the SOW and the Unilateral Order.

Respondents shall perform the following tasks:

TASK I - PROJECT PLANNING

A. SITE BACKGROUND

Respondents shall in the first twenty one days of the Order gather and analyze the existing information regarding the Site and shall conduct a visit to the Site to assist in planning the RD/RA as follows:

A.1 Collect and Analyze Existing Data and Document the Need for Additional Data.

Before planning RD/RA activities, all existing Site data shall be thoroughly compiled and reviewed by Respondents Specifically, this shall include the ROD, RI/FS, and other available data related to the Site. This information shall be utilized in determining additional data needed for RD/RA implementation. Final decisions on the necessary data and DQOS shall be made by EPA.

A.2 Conduct Site Visit

Respondents shall conduct a visit to the Site with the EPA Remedial Project Manager (RPM) during the project planning phase to assist in developing a conceptual understanding of the RD/RA requirements for the Site. Information gathered during this visit shall be utilized to plan the project and to determine the extent of the additional data necessary to implement the RD/RA. Representatives of the State may attend the site visit.

TASK II - PROJECT DELIVERY ANALYSIS

Once Respondents have collected and analyzed existing data and conducted a visit to the Site, the specific project scope shall be planned. The subject document of the work to be conducted shall be the Project Delivery Analysis (PDA).

The Respondents shall submit within twenty one (21) days from the effective date of the Order a Preliminary Project Delivery Analysis (PPDA). Within seven days immediately following the Respondents' submittal of the PPDA, EPA and the Respondents shall conduct a meeting to discuss the document and the design issues detailed below.

Based upon this meeting the structure and schedule of future deliverables shall be determined. Central to this determination is the need to proceed immediately on those portions of the work that must be conducted in an "Expedited" time frame in order that the entire facility may be operational by October 31,1993 (See TASK II, Section D).

The Respondents shall submit a Preliminary Design and a Draft Final Project Delivery Analysis (DFPDA) ninety eight (98) days following the effective date of the Unilateral Order. Within seven (7) days immediatly following the submittal of the DFPDA, EPA and the Respondents shall conduct a meeting to discuss the document.

One hundred and nineteen (119) days from the effective date of the Unilateral Order the Respondents shall submit the Final Project Delivery Analysis.

Upon approval of the Final Project Delivery Analysis, Respondents shall implement the PDA in accordance with the design and construction management schedule contained therein. Plans, specifications, submittals, and other deliverables shall be subject to EPA review and approval in accordance with Section XIV of the Unilateral Order. Review and/or approval of design submittals only allows Respondents to proceed to the next step of the design process. It does not imply acceptance of later design submittals that have not been reviewed, nor that the remedy, when constructed, will meet Performance Standards.

The PDA and subsequent design documents shall provide the technical details for implementation in accordance with currently accepted environmental protection technologies and standard professional engineering and construction practices. The design shall include clear and comprehensive design plans and specifications.

TASK II.A. DESIGN AND CONSTRUCTION STRATEGIES

This section provides information, details, and minimum reporting requirements for inclusion in the Project Delivery Analysis which includes the critical path schedule for design and construction.

The Respondents shall consider and address the following general concepts and obligations with respect to the design of the treatment plant and other facilities. Facilities and construction shall satisfy requirements of the Record of Decision. Design and construction of the treatment plant and other critical components must be undertaken immediately in order to have the facility operational by October 31, 1993.

Timely completion of the project is dependent on the immediate development of the PDA. The PDA will form the basis for subsequent project milestones and will drive the entire project schedule.

The Respondents shall propose a location for the treatment plant in the PPDA. It is important that the treatment plant site selection is completed early in the design process. Potential sites for the plant include Brick Flat Pit (BFP) and Minnesota Flats. While development of the project approach for the treatment plant will be similar regardless of the site selected, other criteria to be developed will vary.

For example, locating the plant at BFP will require extensive road improvements ensuring year-round day-to-day access to the top of the mountain for highway vehicles and provision for extended onsite storage of chemicals to ensure continued treatment during periods when access to the top of the mountain is impaired. Locating the facility low on the mountain will permit a less reliable means of access to BFP and less onsite chemical storage but will require consideration and design for sludge dewatering and staging of dewatered product for transport to BFP.

Critical design components and activities include:

Treatment Plant
Brick Flat Pit Improvements
AMD Conveyance and Utilities
Civil/Site Design
Waste Piles

Task II.A.1 Treatment Plant

ROD2 requires treatment of acid mine drainage (AMD) by the lime/sulfide High Density Sludge (HDS) process. The HDS process decreases the volume of sludge produced, maximizes the projected disposal area life, produces less free liquid potentially available for infiltration, and produces a sludge with favorable dewaterability characteristics. The Respondents shall design the treatment plant to meet the general facility design criteria given in Attachment G, Technical Memorandum TP.03. In addition, the Respondents shall incorporate the monitoring and reporting requirements provided in Attachment J, Technical Memorandum TP.06. The Respondents shall provide to the project a process engineer who is recognized as an expert in the HDS treatment process. This expert shall have a minimum of 5 years experience in waste neutralization using the HDS process. Respondents shall present his or her resume' to EPA for approval prior to the initial work planning meeting between EPA and the Respondents. This person shall be responsible for directing all process and design engineering under this SOW related to the HDS treatment facility.

The Respondents shall address in detail in the PDA the following key elements and design issues for the Treatment Plant:

- Preliminary design of the treatment plant, including site selection, survey and mapping, and final design criteria.

- Determination of AMD equalization requirements. The Respondents shall determine the proper balance of online process treatment capacity and equalization/storage capacity to ensure containment and/or treatment of peak anticipated flows of AMD during winter storm events. Respondents' determination of treatment and storage capacity shall be consistent with the analysis and criteria provided in Attachments F and G, Technical Memoranda TP.02 and TP.03.

- The Respondent shall begin procurement of the major process facilities and supporting equipment early in the design process. Due to the highly specialized nature of the lime/sulfide High Density Sludge process, it is imperative that the main treatment system be engineered by a vendor well experienced in treatment systems of this type. Selection and engagement of such a firm and its inherent recommended process configuration is of paramount importance to the progress of the work. Supporting equipment that is of a long lead procurement nature must be identified and procurement proceedings commenced immediately. These activities must precede and will drive the final design of the overall facility.

Appropriate materials of construction shall be identified, and utilized to ensure long term design function consistent with Attachment H, Technical Memorandum TP.04.

- The Respondent must confirm the need for pilot testing of the lime/sulfide HDS process on Iron Mountain Mine AMD. Because of the extremely high strength of the AMD to be neutralized at this site, it may not be practicable to adequately define the requisite criteria for the process train in the absence of specific testing data. If pilot testing is confirmed as requisite, it must be implemented in accordance with the procurement schedule for the major process equipment.

- Parallel activities to procurement of major process components shall include the provision of all supporting structures and utilities. The Respondent shall develop details and major utility requirements for specific component procurement provisions, and plan installation for the earliest practical date.

Task II.A.2 Brick Flat Pit Improvements

ROD2 requires the disposal of sludge materials in Brick Flat Pit (BFP). Depending on the location of the treatment plant, BFP may be developed as a dry landfill, an impoundment, or a combination (dry in summer and impoundment in winter). Under any of the scenarios, the Respondents shall design the unit to conform with California Group B design requirements unless it can be shown that natural conditions or containment structures will prevent lateral hydraulic interconnection with geologic materials containing groundwater suitable for agricultural, domestic, or municipal use, and that releases will not pollute the waters of the state. The Respondents shall design Brick Flat Pit modifications consistent with the general design criteria given in Attachments C,D, and E, Technical Memoranda TP.01a, TP.01b, and TP.01c. Variations in design criteria that depend upon the treatment plant location are addressed in separate sections within the Technical Memoranda.

The Respondents shall address the following Applicable Group B design requirements; a prohibition of construction in a Holocene fault area, flood protection from a 100-year peak streamflow, liners and filtrate collection systems, precipitation and drainage controls for a 10-year, 24-hour storm event, and specific monitoring requirements. Other design requirements include seismic safety applicable to construction projects in general and the State of California statutes and regulations pertaining to the construction of dams should the site be developed as an impoundment.

The Respondents shall address and detail the following key elements and design issues for BFP in the PDA:

- The Respondents shall propose the type of development based on the proposed plant location, methods of sludge transportation and deposition, and contingencies (e.g., wet weather operations, process changes, etc.)

- The configuration of the sludge disposal area which conforms with the type of sludge development and maximizes the overall volume of sludge which can be disposed of in BFP

- Development strategies such as construction phasing, access, and surface drainage (including roads, conveyance systems, and construction requirements) throughout sludge disposal operations and borrow source operations

- Water quality of BFP discharges, exfiltrate sludge containment, treatment, and control

- Containment system requirements, including:

  - Segregation of existing pyrite orebodies from sludge deposits in BFP

  - Limits and configuration of the lining system and the filtrate collection system within BFP

  - Materials of construction and special design details for providing long-term design function of lining and filtrate collection system components (consistent with Attachment H, Technical Memorandum TP.04)

- Operational equipment, manpower, methods, and special design features required to operate and maintain the disposal area in BFP, including design and/or operational requirements to conform with seasonal or permanent changes in operation

- Intermediate and final cover requirements (including volume and source requirements) based on type of operations, project phasing, and maintenance

Task II.A.3 <u>AMD Conveyance and Utilities</u>

Consistent with ROD2 the Respondents shall construct the necessary structures, pipelines, pipeline appurtenances, and pump stations to provide for delivery of all AMD flows from the Richmond and the Lawson adits for treatment. Criteria for design of the conveyance system components are dependent on the treatment plant location. The Respondents shall design all AMD Conveyance and Utilities to meet the design criteria provided in Attachment G, Technical Memorandum TP.03. Anticipated utilities are the conveyance of uncontaminated water and electrical power distribution.

Uncontaminated water will be required for treatment plant operations. Reliable electrical systems, including backup systems, must be made available at the plantsite and pumping stations.

The Respondents shall address and detail the following key elements and design issues in the PDA for the AMD conveyance system and utilities:

- Final design criteria for conveyance systems and utilities must ensure reliability and incorporate redundancy. A major component of this criteria is the conveyance of peak design flows integrated with treatment plant processes.

- Materials of construction must provide long-term design functionality of system components(consistent with Attachment H, Technical Memorandum TP.04).

- Pipeline routes must provide ease of access for future operation and maintenance. Pipeline construction must be integrated with construction of road improvements.

- Procurement of pumps, supporting equipment, and utilities must proceed on a timely basis to ensure scheduled delivery. Much of the equipment must be designed to convey the extremely corrosive and potentially erosive AMD.

Task II.A.4 <u>Civil/Site Design</u>

The Respondents shall complete a preliminary site layout, develop road alignments, and investigate the stability of the existing soil and rock. The Respondents shall characterize the near-surface material to develop the structural section requirements of the roads and site pavement. The Respondents shall determine geotechnical stability for new structures, and determine minimum cut slopes. The Respondents shall develop Retaining wall locations, benching configurations, if any, and guardrail requirements.

The Respondents shall design the plant site and roads to meet the specific civil design criteria presented in Attachment I, Technical Memorandum TP.05.

The Respondents shall address and detail the following key elements and design issues for the Civil/Site Design in the PDA:

- Plant site selection and adequate topographical mapping,

- Geotechnical assessment is required for design of roads and structures

- Structural improvements shall be made to Flat Creek Bridge and to Iron Mountain Road. These improvements shall meet Shasta County Development Standards and shall be approved by the Director of the Shasta Department of Public Works prior to commencement of construction. Completion of bridge improvements should precede start of onsite construction to allow passage of construction traffic.

- The existing access road on IMM property shall be improved to meet highway vehicle design criteria to the plantsite location. Accessibility to the treatment site shall be provided year-round and day to day to ensure continuous plant operation. The site location selection will dictate the need for either dewatering facilities and a haul road to BFP for sludge transport or a paved road to BFP required to provide year-round reliable access.

- County road improvements, structural improvements to Flat Creek Bridge, and onsite road improvements shall be completed to provide access for construction. These road improvements shall be integrated with construction of the neutralization plant, improvements to BFP, and construction of AMD conveyance and utilities.

Task II.A.5 Waste Piles

Consistent with ROD2, the Respondents shall remediate the seven waste piles, identified as WR-2, -12, -13, -14, -17, -18, and -19 (see Boulder Creek OUFS), to be consolidated onsite and capped in accordance with specified ARARs. The identified piles are largely fine-grained tailings located on relatively steep slopes that are eroding, or may erode into, Boulder Creek. The estimated combined volume of the waste piles is 30,000 to 50,000 cubic yards.

The Respondents shall address and detail the following key issues for waste pile remediation in the PDA:

- Refined characterization of the waste piles to be remediated, so that appropriate disposal measures can be confirmed and followed in accordance with applicable California mining waste reguirements.

- Development of cleanup criteria for the sites of the removed piles.

- Incorporation of surface drainage and erosion control measures appropriate for steep ground at all disturbed areas.

- Completion of all construction activities within the dry season.

- Siting of the onsite disposal facility in accordance with ARARs specified in the ROD2.

- Design, construction, and monitoring of the onsite disposal facility in accordance with specified ARARS and agency approvals.

In conjunction with the development of the PDA and final design of this component of the remedial action, the following items shall be referenced and considered part of this document:

- Specified ARARs given in ROD2

- Design considerations given in Attachments G and J of the Boulder Creek OUFS

TASK II.B. PROJECT DELIVERY ANALYSIS (PDA)

Respondents shall submit a Preliminary, Draft Final and Final PDA in accordance with the requirements of Section IX of the Unilateral Order. The PDA shall be developed in conjunction with the Sampling and Analysis Plan, the Health and Safety Plan, and the Treatability Study Work Plan in the event these are developed. The PDA shall include a comprehensive description of the additional data collection and evaluation activities to be performed and the plans and specifications to be prepared. A comprehensive design management schedule for completion of each major activity and submission of each required deliverable shall also be included.

Specifically, the PDA shall present the following:

a. A statement of the problem(s) and potential problem(s) posed by the Site and the objectives of the RD/RA.

b. A background summary setting forth the following:

   1) A description of the Site including the geographic location and the physiographic, hydrologic, geologic, demographic, ecological, and natural resource features;

2) A synopsis of the history of the Site including a summary of past disposal practices and a description of previous responses that have been conducted by local, State, Federal, or private parties;

3) A summary of the existing data including physical and chemical characteristics of the contaminants identified and their distribution among the environmental media at the Site.

c. A detailed description of each of the activities to be performed, the information needed for each activity, information to be produced during and at the conclusion of each activity, and a description of the work products that shall be submitted to EPA. This description shall identify each of the deliverables required by the Order and this SOW pursuant to Tasks II, III and IV and the activities identified in Attachment B.

d. A schedule for completion of each required activity and submission of each deliverable required by the Unilateral Order and this SOW. This schedule shall also include information regarding timing, initiation and completion of all critical path milestones for each activity and/or deliverable. The schedule shall provide for completing all design and construction activities by October 31, 1993 that are necessary to enable full operation of the treatment plant. A "Strawman" schedule is provided in Attachment B for informational purposes. A comprehensive list of activities with descriptions is provided in Attachment B. The Respondents shall include in the comprehensive schedule all of the activitites listed in Attachment B.

e. A project management plan, including a data management plan, and provision for monthly reports to EPA, and monthly meetings and presentations to EPA. The data management plan shall address the requirements for project management systems, including tracking, sorting, and retrieving the data along with an identification of the software to be used, minimum data requirements, data format and backup data management. The plan shall address both data management and document control for all activities conducted during the RD/RA.

f. A description of the community relations support activities to be conducted. At EPA's request, Respondents will assist EPA in preparing and disseminating information to the public regarding the RD work to be performed.

Task II.B.1 Sampling and Analysis Plan

Respondents shall prepare a Sampling and Analysis Plan (SAP) to ensure that sample collection and analytical activities are conducted in accordance with technically acceptable protocols and that the data generated will meet the DQOs established. The SAP shall include a Field Sampling and Analysis Plan (FSAP) and a Quality Assurance Project Plan (QAPP).

The FSAP shall define in detail the sampling and data gathering methods that shall be used on the project. It shall include sampling objectives, sample location (horizontal and vertical) and frequency, sampling equipment and procedures, and sample handling and analysis. The Field Sampling and Analysis Plan shall be written so that a field sampling team unfamiliar with the Site would be able to gather the samples and field information required. The QAPP shall describe the project objectives and organization, functional activities, and quality assurance and quality control (QA/QC) protocols that shall be used to achieve the desired DQOs. The DQOs shall, at a minimum, reflect use of analytical methods for obtaining data of sufficient quality to meet National Contingency Plan requirements as identified at 300.435 (b). In addition, the QAPP shall address personnel qualifications, sampling procedures, sample custody, analytical procedures, and data reduction, validation, and reporting.

Respondents shall demonstrate in advance and to EPA's satisfaction that each laboratory it may use is qualified to conduct the proposed work and meets the requirements specified in Section IX of the Unilateral Order. EPA may require that Respondents submit detailed information to demonstrate that the laboratory is qualified to conduct the work, including information on personnel qualifications, equipment and material specification, and laboratory analyses of performance samples (blank and/or spike samples).

Task II.B.2 <u>Health and Safety Plan</u>

A Health and Safety Plan shall be prepared in conformance with Respondents's health and safety program, and in compliance with OSHA regulations and protocols. The Health and Safety Plan shall include a health and safety risk analysis, a description of monitoring and personal protective equipment, medical monitoring, and provisions for site control. EPA will not approve Respondents Health and Safety Plan, but rather EPA will review it to ensure that all necessary elements are included, and that the plan provides for the protection of human health and the environment.

Task II.B.3 Schedule

This section details minimum requirements for the Project Delivery Analysis and the related schedule developed through the critical path method (CPM). The PDA will address the timing and interrelationships of all project activities as well as recommended procurement procedures for major equipment and general contractors that will provide for comprehensive construction completion by October 31, 1993. The Respondents shall include all activities listed in Attachment B. The Respondents shall detail design and construction tasks in critical path schedules. Requirements for the schedules include the following:

1. The Respondents shall provide computer-generated network analysis diagram using the critical path method generally outlined in Associated General Contractors of America (AGC) publication The Use of CPM in Construction - A Manual for General Contractors and Construction Industry.

2. The Respondents shall show complete sequence of design and construction by activities, identifying work of separate stages and logical group activities including the critical components. Indicate dates for early and late start, early and late finish, float, and duration.

3. No activity duration exclusive of design tasks listed in the design schedule and the duration for material fabrication and delivery in the construction schedule shall be more than 20 working days.

4. The Respondents shall provide a workable plan for monitoring the progress of all elements of the work, establish the critical elements of work, and forecast potential problems and solutions for maintaining the specified completion date.

Task II.B.4 Treatability study

A treatability study for source control may be conducted by Respondents to ensure that the selected remedy will attain all ARARs as well as any other Performance Standards outlined in ROD2. The study results and operating conditions shall be used in the detailed design of the selected remedy. Treatability study activities shall be planned to occur prior to the additional data collection activities. The results of the treatability study will be evaluated by EPA to determine whether the proposed treatment will attain the ARARs and other Performance Standards specified in the Record of Decision, Order, and this Statement of Work. The Treatability Study Final Report shall be submitted to EPA as soon as possible following completion of the study. The treatability study shall be conducted as follows:

Treatability Study Work Plan

Respondents shall prepare a Treatability Study Work Plan for EPA review and approval. The purpose of the Treatability Study is to determine if the particular technology or vendor of this technology is capable of meeting the Performance Standards. As provided for in the Record of Decision, the Treatability Study Work Plan shall describe the technology to be tested, and test objectives, experimental procedures, treatability conditions to be tested, measurements of performance, analytical methods, data management and analysis, health and safety, and residual waste management. The DQOs for the treatability study shall be documented as well. A schedule for performing the treatability study shall be included with specific dates for the tasks, including, but not limited to, the procurement of contractors and the completion of sample collection, performance, sample analysis, and report preparation. The Work Plan shall describe in detail the treatment process and how the proposed vendor or technology will meet the Performance Standards for the Site. Review and approval by EPA shall mean only that EPA considers the proposed technology, vendor, and study approach appropriate for the remedy selected for the Site. The Treatability Study Work Plan shall also address how Respondents propose to meet all discharge requirements for any and all treated material, water and expected effluents. Additionally, the Work Plan shall also explain the proposed final treatment and disposal of all material generated by the proposed system. Any and all permitting requirements shall also be addressed.

Treatability Study Sampling and Analysis Plan

A separate Treatability Study SAP shall be prepared by the Respondents for EPA review and approval, and shall meet the requirements as discussed above for Task II.B.1.

Treatability Study Health and Safety Plan

A treatability study HSP shall be developed by Respondents. EPA will not approve Respondent's Health and Safety Plan, but rather EPA will review it to ensure that all necessary elements are included, and that the plan provides for the protection of human health and the environment as discussed above for Task II.B.2.

Treatability Study Report

Following completion of the study, Respondents shall submit a report on the performance of the technology to EPA for review and approval. EPA will evaluate the results of the treatability study for completeness and appropriateness based on site conditions. The study results shall indicate clearly the performance of the technology or vendor compared with the Performance Standards established for the Site. The report shall evaluate the treatment technology's effectiveness, implementability, cost, and actual results as compared with predicted results. The report shall also evaluate full-scale application of the technology, including a sensitivity analysis identifying the key parameters affecting full-scale operation. The study results shall be submitted to EPA immediately upon completion of the study. Should the results indicate that the proposed technology will meet the Performance Standards, EPA will instruct Respondents to include the Treatability Study Final Report in the Preliminary Design Report and the study results and operating conditions shall be used in the detailed design of the selected remedy. Approval of the Treatability Study Report by EPA shall mean only that EPA finds the study methodology acceptable. Approval of the study, results, or the Treatability Study Report by EPA shall not imply or be construed to mean that EPA is warranting the performance of this or any vendor or technology. Should the treatability study not be approved by EPA, additional treatability studies may be required to fully evaluate the available treatment systems.

TASK II.C. PRELIMINARY DESIGN/DRAFT FINAL PROJECT DELIVERY ANALYSIS

The Respondents shall submit the Preliminary Design and Draft Final Project Delivery Analysis concurrently. The Preliminary Design/DFPDA deliverable shall reflect <u>only those changes agreed to by EPA and the Respondents</u> pursuant to the work planning meeting required in Paragraph 62 of the Unilateral Order.

Preliminary Design shall begin with initial design and end with the development of the design, for each of the major elements, to the conceptual design stage. Preliminary Design shall include field verification of Site conditions. The technical requirements of the Remedial Action shall be addressed and outlined so that they may be reviewed to determine if the final design will provide an effective remedy. Supporting data and documentation shall be provided with the design documents defining the functional aspects of the project. EPA approval of the Preliminary Design is required before proceeding with further design work, unless specifically authorized by EPA. In accordance with the design schedule established in the Order, Respondents shall submit to EPA the Preliminary Design submittal which shall consist of the following:

Task II.C.1 <u>Results of Data Acquisition Activities</u>

Respondents shall compile summarize, and submit all data gathered during the project planning phase along with an analysis of the impact of the results on design activities. In addition, surveys conducted to establish topography, rights- of-way, easements, and utility lines shall be documented. Utility requirements and acquisition of access, through purchases or easements, that are necessary to implement the RA shall also be discussed.

Task II.C.2 Design Criteria Report

The Respondents shall define the concepts supporting the technical aspects of the design in detail and present them in this report. Specifically, the Design Criteria Report shall include the preliminary design assumptions and parameters, including:

a. Treatment sludges characterization
b. Equalization requirements
c. Volume of AMD requiring treatment
d. Treatment schemes
e. Input/output rates for facilities
f. Influent and effluent qualities
g. Materials and equipment
h. Performance Standards
i. Long-term monitoring requirements

The Respondents shall at a minimum meet the general design criteria specified in Attachments G and I, Technical Memoranda TP.03 and TP.05 and shall be consistent with all the technical attachments to the Order, Attachments B through J.

Task II.C.3 Preliminary Plans and Specifications

Respondents shall submit an outline of the required drawings, including preliminary sketches and layouts, describing conceptual aspects of the design, unit processes, etc. In addition, an outline of the required specifications, including Performance Standards, shall be submitted. Construction drawings shall reflect organization and clarity, and the scope of the technical specifications shall be outlined in a manner reflecting the final specifications.

Task II.C.4 Plan for Satisfying Permitting Requirements

Respondents shall perform all activities in accordance with the requirements of all federal and state laws and regulations. The Respondents shall comply with all requirements identified in Attachment J. Any off-site disposal shall be in compliance with the policies stated in the Procedure for Planning and Implementing Off-site Response Actions (Federal Register, Volume 50, Number 214, November, 1985, pages 45933 - 45937) and Federal Register, Volume 55, Number 46, March 8, 1990, page 8840, and the National Contingency Plan, Section 300.400. The plan shall identify the off-site disposal/discharge permits that are required, the time required to process the permit applications, and a schedule for submittal of the permit applications. The final design plans and specifications must be consistent with the technical requirements of all applicable or relevant and appropriate federal and state environmental regulations unless a waiver has been issued.

Task II.C.5 Preliminary Design Analyses

The evaluations conducted to select the design approach shall be described. Design calculations shall be included.

Task II.C.6 Draft Final PDA

Respondents shall develop the Draft Final PDA and the critical path schedule for construction and implementation of the remedial action which identifies timing for initiation and completion of all critical path tasks. Respondents shall specifically identify dates for completion of the project and major milestones.

TASK II.D. EXPEDITED RD/RA COMPONENTS

Based upon the Preliminary PDA (PPDA), the Respondents shall submit task specific PDAs for those components of the work that are required to be performed in an expedited manner due to long lead times for procurement or construction, or that must be initiated early in the schedule to allow for sequential construction actions. Pursuant to the task specific PDAs, the Respondents shall develop and submit the task specific deliverables, and address the proceedural requirements of the following sections of the SOW for each of the expedited RD/RA components:

Preliminary Design (Task II, Sections B and C),

Pre-Final, Final Design and Construction (Task III, Sections A, B, C, D, E, F, and G).

The Respondents, when developing submittals and deliverables for the following activities outlined in this SOW, shall consider both the expedited work components and the project components that are to be designed and constructed as part of the primary design and construction effort:

Operation and Maintenance (Task IV) and

Performance Monitoring (Task V).

The deliverables listed and described as a part of these Tasks shall address all of the site components as an interactive whole.

TASK III PRE-FINAL/FINAL DESIGN AND CONSTRUCTION

TASK III.A. MAJOR PRE-FINAL AND FINAL DESIGN COMPONENTS

Respondents shall submit the Pre-Final Design when the design work is completed to the detailed design stage (or Draft Final Design) in accordance with the approved design management schedule. Respondents shall address comments generated from the Preliminary Design Review and clearly show any modification of the design as a result of incorporation of the comments. Essentially, the Pre-Final Design shall function as the draft version of the Final Design. After EPA review and comment on the Pre-Final Design, the Final Design shall be submitted in accordance with the schedule approved in the PDA. All Final Design documents shall be certified by a Professional Engineer registered in the State of California. EPA approval of the Final Design is required before initiating the RA, unless specifically authorized by EPA. The Respondents shall submit the following items as part of the Pre-Final/Final Design:

Task III.A.1 Detailed Design Analyses

The selected design shall be presented along with an analysis supporting the design approach. Design calculations shall be included.

Task III.A.2 Detailed Plans and Specifications

A set of detailed construction drawings and specifications shall be submitted which describe the selected design.

Task III.A.3 Final Construction Schedule

Respondents shall revise the PDA critical path schedule and submit a final construction schedule to EPA for review and approval.

Task III.A.4 Construction Cost Estimate

An estimate within +15 percent to -10 percent of actual construction costs shall be submitted.

TASK III.B. MAJOR CONSTRUCTION DELIVERABLES

Concurrent with the submittal of the Pre-final Design, Respondents shall submit a Construction Management Plan, a Construction Quality Assurance Plan, and a Construction Health and Safety Plan/Contingency Plan. The Construction Management Plan, and Construction Quality Assurance Plan must be reviewed and approved by EPA and the Construction Health and Safety Plan/Contingency Plan reviewed by EPA prior to the initiation of the Remedial Action.

Significant field changes to the Construction as set forth in the Final Design shall not be undertaken without the approval of EPA. The construction shall be documented in enough detail to produce as-built construction drawings after the RA is complete. Deliverables shall be submitted to EPA for review and approval in accordance with Section XIV of the Unilateral Order. Review and/or approval of submittals does not imply acceptance of later submittals that have not been reviewed, nor that the remedy, when constructed, will meet Performance Standards.

Respondents shall submit the Final Design to EPA for review and approval as discussed for Task III.A above. The Final Design Submittal shall also provide detailed management plans for completing the construction activities. The Final Design Submittal shall include a comprehensive description of the work to be performed, the final construction schedule for completion of each major activity and all deliverables required pursuant to the Order and this SOW.

Task III.B.1 Construction Management Plan

A Construction Management Plan (CMP) shall be developed to indicate how the construction activities are to be coordinated during the RA. Respondents shall designate a person to be its representative on-site during the Remedial Action, and identify this person in the Plan. This Plan shall also identify other key project management personnel and lines of authority, and provide descriptions of the duties of the key personnel along with an organizational chart. In addition, a plan for the administration of construction changes and EPA review and approval of those changes shall be included. The CMP shall provide for monthly reports to EPA. The CMP shall provide for meetings with and presentations to EPA at the conclusion of each major phase of the Remedial Action. The CMP shall also describe the community relations support activities to be conducted during the RA. At EPA's request, Respondents shall assist EPA in preparing and disseminating information to the public regarding the RA work to be performed.

Task III.B.2 <u>Construction Quality Assurance Plan</u>

Respondents shall develop and implement a Construction Quality Assurance Program to ensure, with a reasonable degree of certainty, that the completed Remedial Action meets or exceeds all design criteria, plans and specifications, and Performance Standards. The Construction Quality Assurance Plan shall incorporate relevant parts of the Performance Standards Verification Plan (see Task V). At a minimum, the Construction

Quality Assurance Plan shall include the following elements:

a. A description of the quality control organization, including a chart showing lines of authority, identification of the members of the Independent Quality Assurance Team (IQAT), and acknowledgment that the IQAT will implement the control system for all aspects of the work specified and shall report to the project coordinator and EPA. The IQAT members shall be representatives from testing and inspection organizations and/or the Supervising Contractor and shall be responsible for the QA/QC of the Remedial Action. The member of the IQAT shall have a good professional and ethical reputation, previous experience in the type of QA/QC activities to be implemented, and demonstrated capability to perform the required activities. They shall also be independent of the construction contractor.

b. The name, qualifications, duties, authorities, and responsibilities of each person assigned a QC function.

c. Description of the observations and control testing that will be used to monitor the fabrication, construction and/or installation of the components of the Remedial Action. This includes information which certifies that personnel and laboratories performing the tests and qualified and the equipment and procedures to be used comply with applicable standards. Any laboratories to be used shall be specified. Acceptance/Rejection criteria and plans for implementing corrective measures shall be addressed.

d. A schedule for managing submittals, testing, inspections, and any other QA function (including those of contractors, subcontractors, fabricators, suppliers, purchasing agents, etc.) that involve assuring quality workmanship, verifying compliance with the plans and specifications, or any other QC objectives. Inspections shall verify compliance with all environmental requirements and include, but not be limited to, air quality and emissions monitoring records and waste disposal records, etc.

e. Reporting procedures and reporting format for QA/QC activities including such items as daily summary reports, schedule of data submissions, inspection data sheets, problem identification and corrective measures reports, evaluation reports, acceptance reports, and final documentation.

f. A list of definable features of the work to be performed. A definable feature of work is a task which is separate and distinct from other tasks and has separate control requirements.

Task III.B.3 Construction Health and Safety Plan / Contingency Plan

A Construction Health and Safety Plan/Contingency Plan shall be prepared in conformance with Respondents's health and safety program, and in compliance with OSHA regulations and protocols. The Construction Health and Safety Plan shall include a health and safety risk analysis, a description of monitoring and personal protective equipment, medical monitoring, and site control. EPA will not approve Respondents' Construction Health and Safety Plan/Contingency Plan, but rather EPA will review it to ensure that all necessary elements are included, and that the plan provides for the protection of human health and the environment. This plan shall include a Contingency Plan and incorporate Air Monitoring and Spill Control and Countermeasures Plans. The Contingency Plan is to be written for the onsite construction workers and the local affected population. It shall include the following items:

a. Name of person who will be responsible for the event of an emergency incident.

b. Plan for initial site safety indoctrination and training for all employees, name of the person who will give the training and the topics to be covered.

c. Plan and date for meeting with the local community, including local, state and federal agencies involved in the cleanup, as well as the local emergency squads and the local hospitals.

d. A list of the first aid and medical facilities including, location of first aid kits, names of personnel trained in first aid, a clearly marked map with the route to the nearest medical facility, all necessary emergency phone numbers conspicuously posted at the job site (i.e., fire, rescue, local hazardous material teams, National Emergency Response Team, etc.)

e. Plans for protection of public and visitors to the job site.

f. Air Monitoring Plan which incorporates the following requirements:

1) Air monitoring shall be conducted both on Site and at the perimeter of the Site. The chemical

constituents that were identified as Contaminants of Concern and any additional compounds identified during the Risk Assessment shall serve as a basis of the sampling for and measurement of pollutants in the atmosphere. Respondents shall clearly identify these compounds and the detection and notification levels required in Paragraph 4 below. Air monitoring shall include personnel monitoring, on-site area monitoring, and perimeter monitoring.

2) Personnel Monitoring shall be conducted according to OSHA and NIOSH regulations and guidance.

3) Onsite Area Monitoring shall consist of continuous real-time monitoring performed immediately adjacent to any waste excavation areas, treatment areas, and any other applicable areas when work is occurring. Measurements shall be taken in the breathing zones of personnel and immediately upwind and downwind of the work areas. Equipment shall include the following, at a minimum: organic vapor meter, explosion meter, particulate monitoring equipment, and onsite windsock.

4) Perimeter Monitoring shall consist of monitoring airborne contaminants at the perimeter of the Site to determine whether harmful concentrations of toxic constituents are migrating off-site. EPA approved methods shall be used for sampling and analysis of air at the Site perimeter. The results of the perimeter air monitoring and the on-site meteorological station shall be used to assess the potential for off-site exposure to toxic materials. The air monitoring program shall include provisions for notifying nearby residents, local, state and federal agencies in the event that unacceptable concentrations of airborne toxic constituents are migrating off-site. Respondents shall report detection of unacceptable levels of airborne contaminants to EPA in accordance with Section XIII of the Order.

g. A Spill Control and Countermeasures Plan which shall include the following:

1) Contingency measures for potential spills and discharges of oil, or Waste Material as defined in the Order, as a result of materials handling and/or transportation.

2) A description of the methods, means, and facilities required to prevent contamination of soil, water, atmosphere, and uncontaminated structures, equipment, or material by spills or discharges.

3) A description of the equipment and personnel necessary to perform emergency measures required to contain any spillage and to remove spilled materials and soils or liquids that become contaminated due to spillage. This collected spill material must be properly disposed of.

4) A description of the equipment and personnel to perform decontamination measures that may be required to remove spillage from previously uncontaminated structures, equipment, or material.

Task III.C. PRECONSTRUCTION CONFERENCE

A Preconstruction Conference shall be held after selection of the construction contractor but before initiation of construction. This conference shall include Respondents and federal, state and local government agencies and shall:

1. Define the roles, relationships, and responsibilities of all parties;

2. Review methods for documenting and reporting inspection data;

3. Review methods for distributing and storing documents and reports;

4. Review work area security and safety protocols;

5. Review the Construction Schedule.

6. Conduct a site reconnaissance to verify that the design criteria and the plans specifications are understood and to review material and equipment storage locations.

The Respondents shall document the Preconstruction Conference, including names of people in attendance, issues discussed, clarifications made, special instructions issued, etc.

Task III.D. PREFINAL CONSTRUCTION INSPECTION

Upon preliminary project completion Respondents shall notify EPA for the purpose of conducting a Prefinal Construction Inspection. Participants shall include the Project Coordinators, Supervising Contractor, Construction Contractor, Natural Resource Trustees and other federal, state, and local agencies with a jurisdictional interest. The Prefinal Inspection shall consist of a walk-through inspection of the entire project site. The objective of the inspection is to determine whether the construction is complete and consistent with the Order. Any outstanding construction items discovered during the inspection shall be identified and noted on a punch list. Additionally, treatment equipment shall be operationally tested by Respondents. Respondents shall certify that the equipment has performed to effectively meet the purpose and intent of the specifications. Retesting shall be completed where deficiencies are revealed. A Prefinal Construction Inspection Report shall be submitted by Respondents which outlines the outstanding construction items, actions required to resolve the items, completion date for the items, and an anticipated date for the Final Inspection.

Task III.E. FINAL CONSTRUCTION INSPECTION

Upon completion of all outstanding construction items, Respondents shall notify EPA for the purpose of conducting a Final Construction Inspection. The Final Construction Inspection shall consist of a walk-through inspection of the entire project site. The Prefinal Construction Inspection Report shall be used as a check list with the Final Construction Inspection focusing on the outstanding construction items identified in the Prefinal Construction Inspection. All tests that were originally unsatisfactory shall be conducted again. Confirmation shall be made during the Final Construction Inspection that all outstanding items have been resolved. Any outstanding construction items discovered during the inspection still requiring correction shall be identified and noted on a punch list. If any items are still unresolved, the inspection shall be considered to be a Prefinal Construction Inspection requiring another Prefinal Construction Inspection Report and subsequent Final Construction Inspection.

Task III.F. FINAL CONSTRUCTION REPORT

Thirty (30) days following the conclusion of the Final Construction Inspection, Respondents shall submit the Final Construction Report. The Final Construction Report shall include the following:

1. Brief description of how outstanding items noted in the Prefinal Inspection were resolved;

2. Explanation of modifications made during the RA to the original PDA and why these changes were made;

3. As-built and record drawings.

4. Synopsis of the construction work defined in the SOW and certification that the construction work has been completed.

Task III.G. REMEDIAL ACTION REPORT

As provided in Section IX of the Order, within 30 days after Respondents conclude that the Remedial Action has been fully performed and the Performance Standards have been attained, Respondents shall so notify the United States and shall schedule and conduct a pre-certification inspection to be attended by EPA and Respondents. If after the pre-certification inspection Respondents believe that the Remedial Action has been fully performed and the Performance Standards have been attained, Respondents shall submit a Remedial Action (RA) Report to EPA in accordance with Section 59 of the Unilateral Order. The RA Report shall include the following:

1. Synopsis of the work defined in this SOW and a demonstration in accordance with the Performance Standards Verification Plan that Performance Standards have been achieved;

2. Certification that the Remedial Action has been completed in full satisfaction of the requirements of the Order, and;

The Remedial Action shall not be considered complete until EPA approves the RA Report.

TASK IV - OPERATION AND MAINTENANCE

Respondents shall develop a Draft O&M Plan and submit it to EPA for review and approval as part of the Final Design. The Draft O&M Plan shall consist of a table of contents and descriptive paragraphs describing the approach to be taken by the Respondents in developing the Draft Final and Final O&M Plan for the project. Respondents shall revise the draft plan pursuant to EPA comments. Respondents shall develop and submit to EPA for review and approval a Draft Final O&M Plan at the approximate 50 percent construction completion stage. Respondents shall revise the plan pursuant to EPA comments. Respondents shall submit the final O&M Plan for

EPA review and approval at the same time that Respondents notify EPA regarding preliminary completion of construction for the purposes of scheduling the prefinal construction inspection.

A. OPERATION AND MAINTENANCE PLAN

At the approximate 50 percent construction completion stage, Respondents shall submit a Draft Final Operation and Maintenance Plan for review. This plan shall describe start-up procedures, operation, troubleshooting, training, and evaluation activities that shall be carried out by the Respondents. The plan shall address the following elements:

1. Equipment start-up and operator training;

   a. Technical specifications governing treatment systems;

   b. Requirements for providing appropriate service visits by experienced personnel to supervise the installation, adjustment, start-up and operation of the systems; and,

   c. Schedule for training personnel regarding appropriate operational procedures once start-up has been successfully completed.

2. Description of normal operation and maintenance;

   a. Description of tasks required for system operation;

   b. Description of tasks required for system maintenance;

   c. Description of prescribed treatment or operating conditions; and

   d. Schedule showing the required frequency for each O&M task.

3. Description of potential operating problems;

   a. Description and analysis of potential operating problems;

   b. Sources of information regarding problems; and

   c. Common remedies or anticipated corrective actions.

4. Description of routine monitoring and laboratory

testing;

a. Description of monitoring tasks;

b. Description of required laboratory tests and their interpretation;

c. Required QA/QC; and

d. Schedule of monitoring frequency and date, if appropriate, when monitoring may cease.

5. Description of alternate O&M;

   a. Should system fail, alternate procedures to prevent undue hazard; and

   b. Analysis of vulnerability and additional resource requirements should a failure occur.

6. Safety Plan;

   a. Description of precautions to be taken and required health and safety equipment, etc., for site personnel protection, and

   b. Safety tasks required in the event of systems failure.

7. Description of equipment;

   a. Equipment identification;

   b. Installation of monitoring components;

   c. Maintenance of site equipment; and

   d. Replacement schedule for equipment and installation components.

8. Records and reporting;

   a. Daily operating logs;

   b. Laboratory records;

   c. Records of operating cost;

   d. Mechanism for reporting emergencies;

   e. Personnel and Maintenance Records; and

f. Monthly reports to State/Federal Agencies.

B. OPERATION AND MAINTENANCE MANUAL

At the 50 percent construction stage, Respondents shall submit a Draft O&M Manual for review. This manual shall include all necessary O&M information for the operating personnel. The O&M Manual must be reviewed and approved by EPA prior to initiation of Operation and Maintenance activities. The Respondents shall submit the final O&M Manual at the same time that they notify EPA regarding completion of construction and scheduling of the Pre-final construction inspection (Task III.D).

TASK V - PERFORMANCE MONITORING

Performance monitoring shall be conducted to ensure that all Performance Standards are met.

A. PERFORMANCE STANDARD VERIFICATION PLAN

The purpose of the Performance Standards Verification Plan is to provide a mechanism to ensure that both short-term and long-term Performance Standards for the Remedial Action are met. Guidance used in developing the Sampling and Analysis Plan during the Remedial Design phase shall be used. The Performance Standards Verification Plan shall be submitted with the Pre-Final and Final Design. Once approved, the Performance Standards Verification Plan shall be implemented on the approved schedule. The Performance Standards Verification Plan shall include:

1. The Performance Standards Verification Field Sampling and Analysis Plan that provides guidance for all fieldwork by defining in detail the sampling and data gathering methods to be used. The Performance Standards Verification Field Sampling and Analysis Plan shall be written so that a field sampling team unfamiliar with the Site would be able to gather the samples and field information required.

2. The Performance Standards Verification Quality Assurance/Quality Control plan that describes the quality assurance and quality control protocols which will be followed in demonstrating compliance with Performance standards.

3. Specification of those tasks to be performed by Respondents to demonstrate compliance with the Performance Standards and a schedule for the performance of these tasks.

REFERENCES

The following list, although not comprehensive, comprises many of the regulations and guidance documents that apply to the RD/RA process. Respondents shall review these guidance and shall use the information provided therein in performing the RD/RA and preparing all deliverables under this SOW.

1. "National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule", Federal Register 40 CFR Part 300, March 8, 1990.

2. "Superfund Remedial Design and Remedial Action Guidance," U.S. EPA, Office of Emergency and Remedial Response, June 1986, OSWER Directive No. 9355.0-4A.

3. "Interim Final Guidance on Oversight of Remedial Designs and Remedial Actions Performed by Potentially Responsible Parties," U.S. EPA, Office of Emergency and Remedial Response, February 14, 1990, OSWER Directive No. 9355.5-01.

4. "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final," U.S. EPA, Office of Emergency and Remedial Response, October 1988, OSWER Directive No. 9355.3-01.

5. "A Compendium of Superfund Field Operations Methods," Two Volumes, U.S. EPA, Office of Emergency and Remedial Response, EPA/540/P-87/001a, August 1987, OSWER Directive No. 9355.0-14.

6. "EPA NEIC Policies and Procedures Manual," EPA-330/9-78-001-R, May 1978, revised November 1984.

7. "Data Quality Objectives for Remedial Response Activities," U.S. EPA, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, EPA/540/G-87/003, March 1987, OSWER Directive No. 9335.0-7B.

8. "Guidelines and Specifications for Preparing Quality Assurance Project Plans," U.S. EPA, Office of Research and Development, Cincinnati, OH, QAMS-004/80, December 29, 1980.

9. "Interim Guidelines and Specifications for

Preparing Quality Assurance Project Plans," U.S. EPA, Office of Emergency and Remedial Response, QAMS-005/80, December 1980.

10. "Users Guide to the EPA Contract Laboratory Program," U.S. EPA, Sample Management Office, August 1982.

11. "Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual," U.S. EPA Region IV, Environmental Services Division, April 1, 1986, (revised periodically).

12. "USEPA Contract Laboratory Program Statement of Work for Organics Analysis," U.S. EPA, Office of Emergency and Remedial Response, February 1988.

13. "USEPA Contract Laboratory Program Statement of Work for Inorganics Analysis," U.S. EPA, Office of Emergency and Remedial Response, July 1988.

14. "Quality in the Constructed Project: A Guideline for Owners, Designers, and Constructors, Volume 1, Preliminary Edition for Trial Use and Comment," American Society of Civil Engineers, May 1988.

15. "Interim Guidance on Compliance with Applicable or Relevant and Appropriate Requirements," U.S. EPA, Office of Emergency and Remedial Response, July 9, 1987, OSWER Directive No. 9234.0-05.

16. "CERCLA Compliance with Other Laws Manual," Two Volumes, U.S. EPA, Office of Emergency and Remedial Response, August 1988 (Draft), OSWER Directive No. 9234.1-01 and -02.

17. "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites," U.S. EPA, Office of Emergency and Remedial Response, (Draft), OSWER Directive No. 9283.1-2.

18. "Guide for Conducting Treatability Studies Under CERCLA," U.S. EPA, Office of Emergency and Remedial Response, Pre-publication Version.

19. "Health and Safety Requirements of Employees Employed in Field Activities," U.S. EPA, Office of Emergency and Remedial Response, July 12, 1981, EPA Order No. 1440.2.

20. "Standard Operating Safety Guides," U.S. EPA, Office of Emergency and Remedial Response,

November 1984.

21. "Standards for General Industry," 29 CFR Part 1910, Occupational Health and Safety Administration.

22. "Standards for the Construction Industry," 29 CFR 1926, Occupational Health and Safety Administration.

23. "NIOSH Manual of Analytical Methods," 2d edition. Volumes I - VII, or the 3rd edition, Volumes I and II, National Institute of Occupational Safety and Health.

24. "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities," National Institute of Occupational Safety and Health/Occupational Health and Safety Administration/United States Coast Guard/ Environmental Protection Agency, October 1985.

25. "TLVs - Threshold Limit Values and Biological Exposure Indices for 1987 - 88," American Conference of Governmental Industrial Hygienists.

26. "American National Standards Practices for Respiratory Protection," American National Standards Institute Z88.2-1980, March 11, 1981.

SUMMARY OF THE MAJOR DELIVERABLES FOR THE REMEDIAL DESIGN AND REMEDIAL ACTION AT THE IRON MOUNTAIN MINE SUPERFUND SITE [OPERABLE UNIT NUMBER #2]

DELIVERABLE	EPA RESPONSE
TASK II PROJECT DELIVERY ANALYSIS	
Preliminary Project Delivery Analysis (PPDA)	Review and Comment
Sampling and Analysis Plan	Review and Approve
Treatability Study Work Plan	Review and Approve
Health and Safety Plan	Review
Comprehensive Schedule/Project Management Plan	Review and Approve
PPDA Meeting Response Letter	Review
Preliminary Design and Draft Final Project Delivery Analysis (DFPDA)	Review and Approve
Results of Data Acquisition Activities	Review and Approve
Design Criteria Report	Review and Approve
Preliminary Plans and Specifications	Review and Approve
Plan for Satisfying Permit Requirements	Review and Approve
Treatability Study Evaluation Report	Review and Approve
Draft Design Analyses	Review and Approve
Draft Plans and Specifications	Review and Approve
Draft Construction Schedule	Review and Approve
Final Project Delivery Analysis	Review and Approve

Monthly Status Reports and Meetings	Review

TASK III PRE-FINAL/FINAL DESIGN AND CONSTRUCTION

Prefinal/Final Design	Review and Approve
Complete Design Analyses	Review and Approve
Complete Plans and Specifications	Review and Approve
Final Construction Schedule	Review and Approve
Construction Cost Estimate	Review
Project Delivery Strategy	Review and Approve
Construction Management Plan	Review and Approve
Construction Quality Assurance Plan	Review and Approve
Construction Health and Safety Plan /Contingency Plan	Review and Approve
Prefinal Construction Inspection Report	Review and Approve
Final Construction Inspection Report	Review and Approve
Remedial Action Report	Review and Approve

TASK IV OPERATION AND MAINTENANCE

Operation and Maintenance Plan	Review and Approve
Operation and Maintenance Manual	Review and Approve

TASK V Monitoring

Performance Standard Verification Plan	Review and Approve

ATTACHMENT B

ACTIVITY DESCRIPTIONS FOR PROJECT

DESIGN AND CONSTRUCTION

AND

PRELIMINARY SCHEDULE

Project Design and Construction Schedule

This section presents a draft design schedule for the timely completion of design and construction of the HDS neutralization plant, Civil/Site and Roadway improvements, AMD Conveyance and Utilities, Brick Flat Pit Improvements, and Waste Pile remediation (see schedule chart). Also included in this section is a description of the minimum required activities for the tasks shown on the schedule. It is anticipated that additional activities, beyond those listed here, may be required for design and construction. The tasks listed in this section shall be included in the design schedule provided to EPA as part of the Project Delivery Analysis. The schedule shall be updated monthly and provided to EPA in the monthly report. Departures from this listing shall be discussed in the Project Delivery Analysis and the Work Plan Meeting. The following listing follows the ID numbering shown on the schedule.

1 Treatment Plant

Activities under this major heading are directed principally at construction of the AMD treatment plant with interfacing activities as required with other elements of the overall Iron Mountain Mine project. It is envisioned that this project element will involve the most specialized design and require the longest lead time in terms of selection and procurement of equipment. It is therefore essential that work begin on this particular project element at the earliest possible date.

2 Plant Preliminary Design

This sub-heading covers a major and critical element to the overall effort of design of the AMD treatment plant. Activities under this umbrella heading serve to encompass the actual critical design decisions, major component selections, and operational strategies for the treatment plant. Activities remaining after completion of this effort should be restricted to developing details and supporting utilities necessary to implement the design already described. Major design decisions or project development should not remain beyond this effort.

3 Site Selection

Two candidate sites have been identified for construction of the AMD treatment plant; basically described as at the top of the mountain at Brick Flat Pit or down gradient of the mine portals at a considerably lower and more accessible site. Key elements of the overall project design rely heavily on the selection of the site, as each site has unique needs and requirements which will affect not only design of the treatment plant but the comprehensive project as well. Thus, a critical element to focusing the overall design and construction effort is to select and confirm this location. The direction of all key elements of this project effort are contingent upon this decision.

4 Final Design Criteria

Key process criteria in terms of AMD flow rates, mass loadings, process configuration, supporting utilities required, and residuals disposition must be fleshed out immediately following site selection. Elements include mass loadings and balances, identification of critical process requirements, reliability and redundancy minimum requirements, treatment objectives, and supporting utility requirements. Further progress of the overall project hinges upon developing and confirming this criteria.

5 Preliminary I&C Strategy

Integral with the development of the major component sizing and selection is the development of an operational control and process monitoring strategy. Taken together these key elements will comprehensively define the overall system design. Development of descriptions of physical facilities will be based on the process and instrumentation requirements as defined in this effort.

6 Preliminary Project Delivery Analysis

The Project Delivery Analysis (PDA) will serve as the single most important document in regard to defining and maintaining control of the interrelated key project elements. This analysis will identify and define methods, schedules, and sequences of events necessary to accomplish a completed and operating project meeting all project objectives within the time frame required. Due to the compressed schedule that this project must meet when compared to traditional municipal design/construct activities, non-traditional approaches are undoubtedly required. Under circumstances of this type, a PDA becomes a prerequisite to project success. The PDA shall include computerized design and construction schedules. These schedules shall be updated and submitted monthly for review by EPA. Since the PDA will form the road map for all ensuing project activities, early development and concurrence of the entire project team is essential.

7 Work Plan Meeting

The work plan meeting will serve as the first major milestone in project development. At this time, the preliminary results of tasks 3 through 6 will be presented, discussed, and closure of the collective group obtained. As the entire project is to build on these cornerstone documents, confirmation of project direction at this point is essential. Project concepts developed to date will be given careful scrutiny by technical and administrative reviewers and unresolved or questionable issues will be identified and tabled for resolution. Review comments and resolution thereof will serve as the vehicle to solidify project concepts and allow the project to proceed in a firm and focused manner, subject to approval by EPA.

8 Finalize I&C Strategy

The preliminary I&C strategy and the results of the review process undertaken at the Work Plan Meeting will form the basis to finalize and firmly establish the I&C strategy for the project. Critical monitoring, control, and telemetry requirements will be finalized and selection of key process components will be confirmed. Concepts such as the type of telemetry, the degree of sophistication of the supervisory control and data acquisition system, level of backup, and system monitoring and transmission of critical alarms will be finalized such that final system configuration and procurement can proceed.

9 Develop Hydraulic Profile

After establishment and confirmation of the final design criteria and process flow configuration, a hydraulic profile will be developed in order to locate in elevation principal process components. This will form the basis for final design of AMD conveyance systems and final grading and configuration of the treatment plant site. After equalization, consideration should be given for gravity flow of AMD through all remaining process structures. Flow shall be maintained under the most critical condition of the largest process component being out of service.

10 Select Equipment and Manufacturers
Upon establishment of the principal components, configuration, and capacity of the selected AMD treatment process, candidate component and system suppliers of the major process elements will be identified. A short list will be developed of vendors and standard components which are capable of meeting minimum performance requirements and are capable of delivering said components or systems within the established project time frame. The most critical element of this analysis is the identification of systems engineering firms well established and experienced in the lime/sulfide high density sludge process, and capable of engineering and delivering a system in accordance with established process specifications. Long lead items in terms of procurement and delivery will be identified such that implementation of procurement procedures may commence immediately.

11 Major Equipment Specifications
The first step in the equipment and system procurement process is the development of detailed specifications for each major component or system. Integral to the technical requirements of the specifications is the development of a protocol for evaluation and selection of the candidate vendors. The specifications will be developed with the understanding that procurement of major process systems must proceed immediately in parallel with other critical design activities. Specifications will be configured for direct bidding by vendors well before finalization of the comprehensive AMD treatment plant construction drawings and specifications.

12 Issue P.O.s for Major Equipment
Once finalized, the major equipment and systems specifications will be issued to identified candidate suppliers. Depending on the complexity of the system or component specified, response from vendors may be in the form of a bid or a system proposal. Vendor responses will be evaluated in accordance with the protocol established in the specification and selections will be made. Upon selection of responsive bidders, purchase orders will be developed and issued such that equipment fabrication may proceed at the earliest possible date.

13 Contingency Plan
Integral with the finalization of the PDA is the development of a contingency plan, the purpose of which is to anticipate the occurrence of unforeseen conditions which could serve to place successful project execution in jeopardy. An alternative course of action will be identified for each identified potential scenario which will mitigate the predicted consequences. Project progress will be monitored continuously and the need for implementation of an element of the contingency plan will be identified at the earliest possible date. It is possible that a contingency plan of action may be implemented in

parallel with the principal course of action in anticipation of less than satisfactory outcome of one of the parallel courses in order to preserve project success.

14 Project Delivery Analysis (Draft Final)
The draft final PDA is a refinement and further elaboration of the preliminary PDA. Since the PDA is expected to be a dynamic document, opportunity must be taken to update and refine project concepts as further information is developed in regard to actual project constraints. Information developed and uncovered during the course of the preliminary design will serve to test concepts forwarded in the preliminary PDA and adjust approaches as required. Incorporation of contingency plans may be required. At this stage of project execution, the PDA should comprehensively define the remaining course of the project and fully address and incorporate EPA review comments .

15 Preliminary Design Submittal
The results of tasks 3 through 14 shall be summarized and submitted for review upon completion of the preliminary design. This review process will be undertaken in preparation for the upcoming Preliminary Design Review Meeting. Project progress, concepts, and execution to date will be reviewed by EPA to ensure that the project is on track. Critical issues will be identified for resolution at the meeting.

16 Preliminary Design Review Meeting
At the Preliminary Design Review Meeting, the Preliminary Design Submittal will be presented and review comments discussed. The purpose of this meeting will be to gain closure on behalf of all parties regarding project direction and progress. It is intended that this meeting will be conducted in a workshop format to maximize the exchange of information and concerns and to identify resolution of critical issues. EPA will summarize results of the meeting and identify actions items noted at the meeting. The Responsible Parties shall formulate the resulting action plan and include these items in the final PDA for EPA review and approval.

17 Plant Final Design
Similar to Task 2, Task 17 is an umbrella title to several ensuing tasks to the preliminary design effort. Plant Final Design is best described as execution of the design formulated in the preliminary design phase. The purpose of this effort is to develop construction, installation, and supporting system details necessary to fully describe implementation of the design already formulated. Development of new concepts should not be planned for this phase.

18 Mechanical
This is a sub-heading of the Plant Final Design whereby design tasks and details are itemized by engineering discipline. The mechanical discipline encompasses process equipment and systems including the instrumentation and control therefor. Supporting utilities in terms of process water, air, plumbing and heating, ventilating, and air conditioning systems are also included.

19 Process, I&C Coordination

The process and instrumentation interaction and coordination will be presented diagrammatically in the process and instrumentation diagrams (P&ID's). These will have been formulated in the Preliminary Design and will form the basis for final design development. Upon confirmation of availability and compatibility of major process components, P&ID's will be confirmed as approved for final construction. All mechanical and I&C components will be specified and constructed in accordance with the approved P&ID's.

20 Equipment Specifications
Specifications describing all supporting process and utility equipment will be developed to comprehensively define all process equipment and installation requirements necessary to support the main treatment process. These specifications will be supplemental and complementary to the major equipment specifications already issued for advanced procurement of principal process systems. These specifications will include items such as moderate to minor pumping systems, chemical feed systems, hoisting systems, air compressors and blowers, emergency power supply generators, motors, etc. Items in these specifications should generally not be of a long lead delivery nature. They are generally concerned with installation and support of the major process systems.

21 Mechanical Drawings
Comprehensive mechanical drawings must be developed describing total installation requirements of all process equipment, piping, and appurtenances. These drawings will integrate pre-purchased major systems and components and all remaining work necessary to furnish a complete and satisfactorily operating system in accordance with the original design concept.

22 Mechanical Specifications
Detailed mechanical specifications will be necessary to describe all mechanical components necessary to provide a complete and operating system in accordance with the original design concept. Mechanical specifications will include items such as major and minor piping systems, valves, meters, gauges, appurtenances, building services, etc.

23 Electrical
This sub-heading of the final design encompasses the electrical discipline. This discipline is responsible for electrical power supply and distribution, power and control wiring, major electrical switchgear, control panels and systems, and all lighting and electrical utility requirements.

24 Electrical Facility Plans
Electrical facility plans are construction drawings that comprehensively describe installation requirements for all electrical support facilities to the major treatment plant components. These facilities include major motor control, conduit and wiring requirements, field panels, lighting and receptacle requirements, protection and backup systems, and power and control system terminations and interconnections. It is intended that these drawings will provide all necessary installation requirements and details required to provide a complete and operable system in accordance with the established

design concept.

25 Electrical Control Diagrams
Electrical control diagrams are intended to describe major process equipment wiring and control requirements. These control diagrams will form the basis for configuration of the major equipment power distribution and control. The diagrams are essential for proper coordination and installation of all electrically powered and/or controlled equipment.

26 Detailed Electrical Specifications
Supporting the electrical drawings are detailed component specifications for all electrical distribution, control, and utility requirements. Specifications will comprehensively describe all conduit, wiring, transformers, switchgear, motor control, field panels, lighting and receptacle components, etc. Specifications will be complementary to the electrical drawings and, when taken together, will form all necessary information as required to provide a complete and operable project.

27 Final Process and Instrumentation
Based upon information as described in the P&ID's, detailed instrumentation and control specifications, installation details, panel elevations, and necessary panel wiring and block diagram drawings will be developed. This design element will encompass all instrumentation components, loop descriptions, interface connections with major process components, telemetry, and factory and field testing and startup procedures. These details will support construction and installation necessary to provide a complete and operable system.

28 Structural
This sub-heading of the final design process encompasses the structural discipline. This discipline is responsible for all foundations, slabs, process and non-process structures and buildings, and miscellaneous structural components and elements necessary to support the entire project. All mechanical components which comprise structural elements must be designed, furnished, and anchored in accordance with the requirements of the structural discipline.

29 Structural Plans
Descriptive plans will be developed for all structural elements in support of the main process facilities. These plans will include foundation plans for all elements, and plan, sections, and details of all structural elements and components that are not supplied as part of a vendor-engineered package system. Supporting requirements for all mechanical components not already comprehensively specified will be included.

30 Structural Specifications
In support of the structural plans and details, descriptive specifications will be developed to define structural elements and materials of construction. Specifications will cover, in general structural concrete, masonry, metals, wood and plastics, thermal and moisture protection, and miscellaneous building specialties. As with the other disciplines, the

intent of the structural specifications is to completely describe all structural work necessary to support the main process design and provide a complete and comprehensive facility.

31 Prefinal Design Submittal
The complete package of all civil, structural, mechanical, electrical, and instrumentation and control plans and specifications necessary to define all construction requirements to support and complete installation of the AMD treatment plant shall be assembled into a Prefinal Design Submittal. This package shall be submitted to EPA for review in preparation for the Prefinal Design Meeting. Review will be conducted to ensure that the project is proceeding in accordance with the concepts set forth in the Preliminary Design. Review will be conducted as expeditiously as possible and review findings will be presented and discussed at the meeting.

32 Prefinal Design Meeting
The Prefinal Design Meeting will be held in similar "workshop" format to the Preliminary Design Review Meeting. The purpose of the meeting will be to present, discuss and gain closure on critical design issues resulting from review of the Prefinal Design Submittal. EPA will prepare a summary of the results of the meeting and will identify all action items remaining from the workshop necessary to complete closure.

33 Plant Construction
This major heading is intended to concentrate on those activities associated with preparation of the site and construction/installation of all foundations, utilities, and necessary support equipment and systems, and the major process components comprising the complete AMD treatment plant. Construction activities must commence to the degree practicable at the earliest possible date in order to meet the overall project schedule. A key consideration of the PDA will be to identify those construction activities that can be commenced prior to the completion of final design. It is the intent of this accelerated construction program to release for construction identified elements of the project as they become fully described.

34 Initial Site Preparation
From the standpoint of the AMD treatment plant design, the first likely element of construction to be released for construction is the initial site preparation element. Initial site preparation entails major rough grading of the site in preparation for the construction of the facilities. Upon identification of the site, basic facility layout, and hydraulic profile, enough information should exist to allow preparation of the site in terms of defined benches and mass balances. Advanced site preparation of this nature will accomplish a time consuming prerequisite to final site preparation that need not wait for final construction details to be effectively accomplished.

35 Final Site Preparation
Final site preparation may be commenced upon finalization and release for construction of the final site plans and road grading plans. It is anticipated that rough grading will be accomplished in advance of this construction element's "ready for construction" date.

This activity will comprise the finished grading and preparation for construction of the major process component foundations and interconnecting piping, wiring, and other miscellaneous support utilities.

36 Foundation and Structures

Foundations and structures will be released for construction upon finalization of shop drawings and installation details of the major process structures and equipment. Construction of these major process elements should be scheduled such that the site will be in a state of readiness to receive and install the major equipment immediately upon delivery in accordance with the schedule established in the procurement documents.

37 Install Equipment

It is anticipated that upon successful execution of site preparation and construction of critical foundations and other complementary structures, installation of equipment can proceed immediately upon scheduled delivery. The equipment procurement and installation will undoubtedly be a principal element of the project critical path and all construction activities must be focused to be in a state of readiness to proceed with all deliberate speed on this task. To expedite the installation process and to minimize the possibility for schedule impeding errors or delays, it is strongly suggested that the on-site presence of principal manufacturer's representatives be mandated throughout this critical installation period.

38 Shakedown

Upon completion of installation, all equipment and systems must undergo functional and performance testing to demonstrate readiness to operate in a continuous service mode. Once individually tested, these systems must undergo a minimum period of total system simulated operation to demonstrate the ability of the entire AMD treatment plant to function reliably and in concert with all project program elements. Upon successful completion of all functional, performance, and reliability demonstration testing, the system will be declared to be in a state of substantial completion and "ready for operation." At this point, the AMD treatment plant will be deemed to be in a state of readiness to receive and treat AMD in accordance with the Record of Decision from this day forward. Non critical construction items necessary to complete the permanent and long-term operating facility may still remain at this point and continuation of the construction process is permissible as long as the ability to receive and treat AMD remains unimpeded.

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40 Civil/Site & Roads

Activities under this major heading are directed principally at design and construction of the treatment plant site earthwork, drainage, paving, and county and private access roadways to the site location. Subheadings separate design and construction phases for the plant site civil work, county road and county bridge improvements, and private access road improvements and/or new construction.

41 Preliminary Civil/Site & Roads Design

This sub-heading covers the plant site location selection and concurrent surveying and mapping of the existing access roads and probable plant site locations.

42 Preliminary Plant Site Plans
A critical element to the success of this "fast track" design and construction approach is the early selection of the plant site location. Preliminary plant site plans for each potential site will be required for the evaluation of the final site location. Plans shall show potential layouts and equipment requirements, and preliminary area and access needs.

43 Site Selection
As described in Task 3, the early selection and confirmation of a final plant site location is required for critical design elements to proceed in a timely manner.

44 Survey and Mapping
Aerial photography, topographical mapping, and development of topographical triangular network (.TTN) files will be required for subsequent CAE civil design and for creating graphics in final design plans. It is anticipated the aerial photography will be done prior to final site location and will include coverage of the three candidate sites and existing roadways to these sites. Topographical mapping for access roads common to the potential sites can be started prior to final site selection. Completion of the mapping and .TTN files will likely occur after site selection has been confirmed.

45 Final Design Criteria
Key civil design criteria in terms of plant area requirements, traffic patterns and quantities, and AMD and utility routing must be defined immediately following site selection. Reference criteria presented in Technical Memorandum TP.05.

46 Preliminary Plant Layout
Based on site location, preliminary structure sizes, locations, and vehicle access requirements must be defined. This sub-headings shall be coordinated with Plant Preliminary Design.

47 Work Plan Meeting
The work plan meeting will include project designers, and technical and administrative reviewers. At this time, project concepts developed to date will be presented and scrutinized. Unresolved issues will be identified and tabled for resolution. Mileposts defined in the PDA will be reviewed and adjusted to assure completion of preliminary design within the established PDA schedule.

48 Geotechnical Assessment
This sub-heading includes definition and execution of a geotechnical assessment of existing soil conditions. This will include plant site foundation design criteria, onsite and offsite road pavement section design criteria, and maximum cut slopes. Refer to Technical Memorandum TP.05.

49 Preliminary AMD Routing

The preliminary AMD routing drawings should consist of conceptual drawings of the AMD conveyance system including, but not limited to, a scaled representation of the plant site, portal locations, and routing of the AMD conveyance system.

50 Preliminary Utility Routing

The preliminary utility routing drawings should consist of conceptual drawings of the routing for utilities including noncontaminated water from the source to the processing plant, and routing of electrical lines.

51 Preliminary Design Submittal

The results of tasks 42 through 50 shall be summarized and submitted for review upon completion of the preliminary civil/site design. This review process will be undertaken in preparation for the upcoming Preliminary Design Review Meeting. Project progress, concepts, and execution to date will be reviewed by EPA to ensure that the project is on track. Critical issues will be identified for resolution at the meeting. The preliminary design submittal should include, but not be limited to, conceptual drawings for the plant layout, AMD routing, and utility routing. The preliminary design submittal shall also include a design report detailing the final design criteria and the basis for the plant site selection.

52 Preliminary Design Review Meeting

At the Preliminary Design Review Meeting, the Preliminary Design Submittal will be presented and review comments discussed. The purpose of this meeting will be to gain closure on behalf of all parties regarding project direction and progress. It is intended that this meeting will be conducted in a workshop format to maximize the exchange of information and concerns and to identify resolution of critical issues. EPA will summarize results of the meeting and identify actions items noted at the meeting. The Responsible Parties shall formulate the resulting action plan and include these items in the final PDA for EPA review and approval.

53 Preliminary Road Design

This task includes assessment and preliminary design of Flat Creek Bridge, and the preliminary design of onsite and offsite roads. It is essential that access to the site be improved as soon as possible for construction of the plant and other construction to proceed.

54 Flat Creek Bridge Assessment

In order for construction to proceed, it is imperative that improvements to Flat Creek Bridge be completed as soon as possible. This task should include a preliminary structural and geotechnical evaluation. Contact shall be initiated with the appropriate Shasta County agencies. Meetings with representatives from Shasta County shall be completed prior to the work plan meeting.

55 Work Plan Meeting

The work plan meeting with EPA and Shasta County shall include presentation of the assessment of Flat Creek Bridge. A representative of Shasta County will coordinate final design review and pre-approvals of final documents prior to commencing construction. A schedule for completion of design and construction of Flat Creek Bridge should be presented.

56 Flat Creek Bridge Preliminary Design
Preliminary Design drawings shall be generated showing modifications to the bridge over Flat Creek. Plans and notes shall meet Shasta County Development Standards.

57 Flat Creek Bridge Submittal
Preliminary design drawings for Flat Creek Bridge shall be submitted to Shasta County and EPA for review. Design and drawings should follow requirements of Technical Memorandum TP.05. This review process will be undertaken in preparation for the upcoming Flat Creek Bridge Review Meeting. Project design, drawings, and schedule will be reviewed by EPA to ensure that the project is on track. Critical issues and coordination with the Shasta County Public Works Department will be discussed at the meeting.

58 Flat Creek Bridge Review Meeting
Preliminary design criteria and preliminary design shall be reviewed at this meeting. The purpose of the meeting is to expedite all final design issues.

59 Onsite Roads
Preliminary design drawings should show existing private roadway modifications, new horizontal and vertical road alignments, if any, typical road sections and details. Plans and notes shall meet requirements of Technical Memorandum TP.05.

60 County Roads
Preliminary design drawings showing county road improvements, new alignments, if any, typical road sections and details shall be generated. Notes and plans shall meet requirements of Technical Memorandum TP.05.

61 Preliminary Road Design Submittal
The preliminary road design submittal to Shasta County and EPA shall include preliminary design drawings for onsite and offsite roads. Design and drawings should follow requirements of Technical Memorandum TP.05.

62 Preliminary Road Design Review Meeting
The preliminary design review meeting with Shasta County and EPA will be a meeting to review design criteria and preliminary design drawings. The purpose of the meeting is to resolve all final design issues.

63 Flat Creek Bridge Final Design
Activities under this sub-heading are directed toward the timely design completion and pre-approval of the construction documents by the Shasta County Department of Public Works.

64 Flat Creek Bridge
This task includes final design drawings, calculations and specifications for Flat Creek Bridge, including plans, sections, details, and notes. Approval of the final design must be obtained from Shasta County. The final design drawings and calculations should meet requirements of Technical Memorandum TP.05.

65 Prefinal Design Submittal
Prefinal design drawings, specifications, and documentation for alterations to Flat Creek Bridge shall be submitted to Shasta County and EPA for review in preparation for the Prefinal Design Meeting. Review will be conducted to ensure that the project is proceeding in with the concepts set forth in the Preliminary Design. Review will be conducted as expeditiously as possible.

66 Prefinal Design Meeting
The Prefinal Design Meeting for Flat Creek Bridge will be held in similar "workshop" format to the Preliminary Design Review Meeting. The purpose of the meeting will be to present, discuss and closure on critical design and construction schedule issues resulting from review of the Prefinal Design Submittal. EPA will prepare a summary of the results of the meeting and will identify all action items remaining from the workshop necessary to complete closure and ensure timely start of Bridge construction/reconstruction.

67 Roads Final Design
Activities under this sub-heading include completion of final design documents for work on onsite private access roads as well as county-owned access roadways.

68 County Roads
This task includes completion of final design drawings and calculations for county road construction, including plans, sections, details, and notes. Approval of the final design must be obtained from Shasta County. The final design drawings and calculations should meet requirements of Technical Memorandum TP.05.

69 Onsite Roads
This task includes completion of final onsite road construction drawings, including plans, sections, details, and notes. The final design drawings and calculations should meet requirements of Technical Memorandum TP.05.

70 Prefinal Design Submittal
Prefinal design drawings, specifications, and documentation for county and onsite road improvements shall be submitted to Shasta County and EPA for review in preparation for the Prefinal Design Meeting. Review will be conducted to ensure that the project is proceeding in accordance with the concepts set forth in the Preliminary Design. Review will be conducted as expeditiously as possible.

71 Prefinal Design Meeting
The Prefinal Design Meeting for roads will be held in similar "workshop" format to the

Preliminary Design Review Meeting. The purpose of the meeting will be to present, discuss and gain closure on critical design and construction schedule issues concerning county and onsite road improvements. EPA will prepare a summary of the results of the meeting and will identify all action items remaining from the workshop necessary to complete closure and ensure timely start of Bridge construction/reconstruction.

72 Civil/Site Final Design
Activities under this sub-heading include completion of final design documents for work on onsite civil, earthwork, drainage, and paving design.

73 Civil/Site Plans
Complete sitework/civil design drawings, including plans, sections, details, and notes. The final design drawings and calculations should meet requirements of Technical Memorandum TP.05.

74 Civil/Site Specifications
In support of the Civil/Site plans and details, descriptive specifications will be developed to define civil elements and materials of construction. Specifications will cover in general dust control, mobilization, general provisions, grading, subbases and bases, surfacings and pavements, drainage facilities, right of way and traffic control.

75 Prefinal Design Submittal
Prefinal design drawings, specifications, and documentation for onsite civil/plant site improvements shall be submitted to EPA for review in preparation for the Prefinal Design Meeting. Review will be conducted to ensure that the project is proceeding in accordance with the concepts set forth in the Preliminary Design. Review will be conducted as expeditiously as possible.

76 Prefinal Design Meeting
The Prefinal Design Meeting for civil/site improvements will be held in similar "workshop" format to the Preliminary Design Review Meeting. The purpose of the meeting will be to present, discuss and gain closure on critical design and construction schedule issues concerning onsite civil/plant site improvements. EPA will prepare a summary of the results of the meeting and will identify all action items remaining from the workshop necessary to complete closure and ensure timely start of construction.

77 Road Construction
This task includes activities associated with the construction of private and county road and bridge construction/reconstruction. Pre-approval of construction documents and schedules must be coordinated with Shasta County to allow construction to commence as soon as final design documentation has been reviewed and approved.

78 Flat Creek Bridge Construction
Structural improvements to the bridge over Flat Creek shall be scheduled for construction

in advance of the main plant site construction to allow construction-related vehicle loads to access the site. Consideration shall also be given to traffic control and access beyond the bridge during construction activities.

79 County Road Construction
Traffic control and construction of structural improvements to the existing county road shall be pre-approved by the Shasta County Department of Public Works. Construction shall commence immediately following final design review and approval.

80 Onsite Road Construction - Phase 1
It is anticipated that onsite road rough grading may be required in advance of the final site construction. Separation of construction phases for the plant site access roads will allow flexibility in meeting final construction schedules.

81 Onsite Road Construction - Phase 2
This phase of plant site access road construction includes final grading, drainage, and surface preparation. This work shall be done in conjunction with task 33, Plant Construction.

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83 AMD Conveyance and Utilities
This is the main task heading for design and construction of the required AMD conveyance and utility systems. The AMD conveyance systems shall consists of the pipeline, pump stations and electrical controls designed according to the criteria presented in Technical Memorandum No. TP.03 necessary for transmission of AMD from the Richmond and Lawson portals to the selected treatment plant site. Utilities shall consist of conveyance of uncontaminated water and the construction of adequate electrical power utilities to operate the treatment plant and all conveyance system pump stations. Conveyance systems for uncontaminated water shall consists of pump stations, pipelines and electrical controls designed according to the criteria as described above needed for transmission of water from local streams to the selected treatment plant site. Electrical utilities shall include all the necessary power poles, wiring, and transformers as directed and/or installed by the Pacific Gas and Electric Company (PG&E). Tasks under this main heading are numbered 84 through 103.

84 Preliminary design
This task heading designates the preliminary design phase for tasks numbered 85 through 97. During this phase the following key design tasks shall be performed:

- Initial field data are collected and analyzed.
- Base mapping is completed for all design drawings based on information from Task No. 44.
- Final design criteria are identified for EPA approval.
- Conveyance and utility facilities are located, sized, and initially laid out.
- The resulting preliminary conveyance and utility facilities are presented

and approved prior to final design.

85 Final Design Criteria
Under this task all final design criteria shall be identified for design. The criteria presented in Technical Memorandum No. TP.03 shall be reviewed, added to and amended as required for design of conveyance and utility systems with a 30 year service life.

86 Work Plan Meeting
This meeting with EPA will serve as the first major milestone in project development. Major tasks of the preliminary design will be presented and discussed for EPA approval. Critical components presented by the Responsible parties and addressed in the PDA include:

- Final Design criteria.
- Surveying and mapping coordination with design.
- Pipeline routes and pump station locations.
- Equipment with long delivery times.
- Special design considerations required, including geotechnical, corrosion design, hydraulic and surge analyses.
- The preliminary design submittal.

87 Pipeline Route Selection
In this task, all pipeline routes shall be preliminarily identified on the appropriate base mapping, completed in Task 44, so that pipeline plan and profile sheets can be developed. A field review shall be completed to verify the selected routes. Route selection shall follow the design criteria established in Technical Memorandum No. TP.03. An important factor in route selection will be accessibility for ease of operation, maintenance and system reliability.

88 Pump Station Locations
In this task, pump station locations shall be identified on base mapping and verified by a field review. This information shall be given to the survey crews so that site topographic maps can be developed.

89 Electrical Utility Locations
This task includes two major subtasks:

- A map shall be developed showing the locations of the selected treatment plant site and all pump station locations along with estimated power requirements at each location. This map shall then be given to the appropriate PG&E representative for assistance in design of a reliable power transmission system needed at the treatment plant and the various pump stations.

- Continued coordination with PG&E to facilitate design, material/equipment selection and construction of the new power transmission system along with the interfacing of the existing power supply system.

90 Pump Station Component Layout

In this task, site topographic maps developed in Task 44 will be used to initially design the individual pump stations required for conveyance of AMD and uncontaminated water. Pump station components and necessary appurtenances will be identified. Identified components include, but are not limited to, the following:

- Master control panel assemblies.
- Pump and motor assemblies and appurtenances.
- Standby generators.
- HDPE storage tanks.
- Valves, interconnection piping and fittings.
- Structures.
- Telemetry control system/s.

91 Pipeline Appurtenances

In this task major pipeline appurtenances are identified. Identified appurtenances include, but are not limited to, the following:

- Stainless steel air valve assemblies.
- Pipeline drain (Blow off) assemblies.
- Isolation valves.
- Contraction/Expansion loops.
- Thrust restraint systems.
- Pipeline fittings/joints.
- Miscellaneous Structures at Portals and intermediate locations along the various pipeline routes.

92 Hydraulic Analysis

For this task a hydraulic analysis shall be performed that will verify the size of all pipelines and pump stations for the various flow conditions presented in Technical Memorandum No. TP.03. This analysis shall be completed using a standard computer hydraulics program and the results presented as a written report. This report will be used as a basis for the Surge Analysis.

93 Select Equipment

In this task, two subtasks shall be performed:

- Outline specifications shall be developed for all equipment. These specifications shall include the specification title and a brief description what the specification will contain.
- Pipeline and pump station components shall be identified that have significant manufacturing time requirements. Long lead items for procurement and delivery will be identified in the PDA for the upcoming Preliminary Design Review meeting. Some of the critical components may include:
    - Stainless steel air valves incorporating materials based on Technical Memorandum No. TP.04 and Task 95.
    - HDPE pipe.

- AMD Slurry Pumps and Motors.

94 Surge Analysis
A surge analysis will be performed using the results of the hydraulics analysis. The analysis shall be performed using a computer program that predicts high surge pressures that usually occur during power failures. This information shall then be used to determine if the conveyance system can withstand the surge without damage. The analysis will also present solutions in case the existing conveyance system design will be damaged from the surge pressures. This report shall be presented as a written report.

95 Corrosion Design
In this task, an evaluation shall be completed using the information from Technical Memorandum No. TP.04-Materials of Construction to determine the required corrosion protection for pipeline and pump station components in the IMM environment for a 30 year project service life. The results of this analysis will be used in concert with Task 93 Selection of Equipment. A field survey will be required with appropriate testing of soils, existing reinforced concrete structure performance and AMD fluid properties.

96 Preliminary Design Submittal
In this task, preliminary design drawings and outline specifications shall be sent to EPA for review.

97 Preliminary Design Review Meeting
In this task a meeting shall be held with EPA to review the key elements of the Preliminary Design including:

- The results of the hydraulic, surge, corrosion, and geotechnical analysis.
- Design changes created by these analysis.
- Preliminary drawings and outline specifications.
- Equipment prepurchase status, if required.
- Status of coordination with PG&E.
- The PDA.

EPA will summarize results of the meeting and identify actions items noted at the meeting. The Responsible Parties shall formulate the resulting action plan and include these items in the final PDA for EPA review and approval.

98 Final Design
This is the main task heading for the final design phase for Tasks 99 through 102. In this phase, plans and specifications developed in the preliminary design phase are completed.

99 Plans
Under this task the all drawings required to construct the AMD conveyance and utility systems are completed. Drawings include but are not limited to:

- Location maps.

- Pipeline plan and profile drawings.
- Pump station drawings.
- Electrical control drawings.
- Detail sheets.

100 Specifications
In this task the outline specifications developed in the preliminary design phase shall be completed in concert with the plans described in Task No. 91. Specifications shall be thoroughly checked against the plans to insure that all construction components are specified.

101 Prefinal Design Submittal
The complete package of all calculations, plans and specifications necessary to define all construction requirements to support and complete installation of the AMD Conveyance and utilities shall be assembled into a Prefinal Design Submittal. This package shall be submitted to EPA for review in preparation for the Prefinal Design Meeting. Review will be conducted to ensure that the project is proceeding in accordance with the concepts set forth in the Preliminary Design. Review will be conducted as expeditiously as possible and review findings will be presented and discussed at the meeting.

102 Prefinal Design Meeting
The Prefinal Design Meeting will be held in similar "workshop" format to the Preliminary Design Review Meeting. The purpose of the meeting will be to present, discuss and gain closure on critical design issues resulting from review of the Prefinal Design Submittal. EPA will prepare a summary of the results of the meeting and will identify all action items remaining from the workshop necessary to complete closure.

103 AMD Conveyance & Utility Construction
Under this task construction shall be completed for the following system components:

- AMD pump station(s).
- AMD pipelines, appurtenances, and conveyance structures.
- Uncontaminated water supply pump station/s.
- Uncontaminated water supply pipelines, appurtenances, and conveyance structures.
- Coordination with PG&E on construction of electrical power utilities.

104 blank

105 BFP Improvements

106 Preliminary Design

107 Final Design Criteria
This task includes the selection of minimum criteria and design basis for developing the landfill in accordance with its intended function and applicable operational, regulatory, and safety requirements. These criteria should include, but not limited to, minimum

materials and performance requirements for linings, filtrate collection, and pipe components, filter criteria, minimum static and seismic factors of safety, performance requirements for drainage structures (e.g. design storm, erosion protection, sediment control), maximum slope requirements (e.g. slope angle, slope height, bench configuration, and minimum static and seismic factors of safety), minimum interim and final cover requirements (including components, stability, etc.), maximum road grades, minimum turning radii, etc.

108 Initial Site Layout

The initial site layout should consist of conceptual-level drawings showing the planned sequence of landfill development in sufficient detail to demonstrate that the design requirements are understood and to show the designer's concept for meeting the requirements of the Record of Decision (ROD). These drawings should include, but not be limited to, conceptual plan and cross-section views showing the conceptual configuration and phasing of the landfill, roadway network, drainage facilities, and containment system components in adequate detail to identify a logical development and operational sequence, and to show the configuration and interaction of major design components.

109 Work Plan Meeting

The work plan meeting will be a review meeting with the Respondents, with EPA and all review parties to discuss the conceptual design and design criteria, to get all review comments and concerns on the table, and to come to an agreement as to the direction the remainder of the design will go. The meeting will be documented by a follow-up letter which will include all agreed-upon modifications, if any, so that the design may proceed without delay.

110 Preliminary Site Layout

The preliminary site layout should develop the agreed-upon conceptual design into a design package showing the configuration of the various phases of landfill development and the location and configuration of the major design components for each. Preliminary design documents should include adequate plan views, cross-sections, details, materials identification, and computations to demonstrate that the various components of the design have been developed and sized to meet the design and performance criteria for the project.

111 Preliminary Operational Plan

The preliminary operational plan should contain a description of the planned method of operation of the landfill. It should contain a description of the operational and phasing concept, personnel and equipment requirements, proposed operations and maintenance procedures, including contingencies for bad weather and other contingencies.

112 Preliminary Monitoring Plan

The preliminary monitoring plan should include a description of the planned methods for monitoring the landfill site during operations. It should include provisions for groundwater, surface water, filtrate, acid seep, and air monitoring in accordance with all applicable state and federal monitoring requirements and requirments listed in Technical Memorandum TP.06.

113 Preliminary Design Submittal
The preliminary design submittal should include copies of preliminary site layout, operational, and monitoring documents as described above.

114 Preliminary Design Review Meeting
The preliminary design meeting will be a review meeting with EPA, the Respondents, and all review parties to discuss the discuss preliminary design review comments and to get all review comments and concerns on the table, and to come to an agreement on modifications, if any, which will be required during the final design step. EPA will summarize results of the meeting and identify actions items noted at the meeting. The Responsible Parties shall formulate the resulting action plan and include these items in the final PDA for EPA review and approval.

115 Final Design

116 Liner and Filtrate System Design
Final design of the liner and filtrate system components should include the final plans, cross-sections, construction details, and specifications in sufficient detail that a contractor can locate and install, complete, all liner and filtrate collection components to the limits and configurations required to meet the performance objectives of the design. Where the lining and filtrate system components are to be installed over two or more phases, details of phased construction, extensions, and connections should be included.

117 Pyrite Segregation Design
Final design of the pyrite segregation component should include final plans, cross-sections, construction details, and specifications in sufficient detail for a contractor to locate and install, complete, all grading, linings, seep collection, and protective cover materials to permanently segregate and collect for treatment seepage which comes from the ore materials in the western end of the pit. This system should also include details and specifications for sumps, pumps, piping, and other conveyance system components for transporting contaminated seepage to the treatment works.

118 Precipitation and Drainage Control
Final design of precipitation and drainage controls should include final plans, cross-sections, construction details, and specifications in sufficient detail for a contractor to install, complete, drainage ditches, culverts, channel protection, sediment controls and other drainage control devices at the locations and to the configurations of the design. These features should be included for each phase of the project.

119 Filtrate Discharge System
Final design of the filtrate discharge system should include final plans, construction details, and specifications in sufficient detail for a contractor to install, complete, the discharge pipe, sumps, pumps, outlet works, and/or monitoring stations as required to

provide for collection, testing and proper disposition of filtrate from the filtrate collection system.

120 Final Operational Plan

The final operational plan should include a comprehensive updating of the preliminary operational plan to provide a final plan for operating and maintaining the landfill under expected operating conditions. The update should include agreed-upon modifications to the preliminary plan and any additional information which may become apparent during the final design phase. The document should be an easily updated handbook which contains easy to follow directions and procedures for operational, maintenance, and reporting requirements.

121 Final Monitoring Plan

The final monitoring plan should include a comprehensive updating of the preliminary monitoring plan to provide a final plan for monitoring the landfill. The update should include agreed-upon modifications to the preliminary monitoring plan and additional monitoring requirements, if any, noted during the final design phase. The document should be an easily updated handbook which contains frequencies, procedures, and reporting requirements for monitoring.

122 Sludge Transportation Plan

The sludge transportation plan should include comprehensive procedures for transporting sludge materials to the landfill. It should include, at a minimum, discuss the routing, operation, and maintenance of transport facilities (trucks, conveyors, pipelines, etc., as applicable), maintenance of accessways, contingency operations, and spill containment and abatement. As with the other operational plans, the sludge transportation plan should be an easily updated handbook which provides ready reference to applicable procedures and requirements. This task shall include the design of the BFP discharge conveyance system described in Technical Memorandum 1c.

123 Sludge Storage Design

The sludge storage design shall include complete plans and specifications for lagoons and/or temporary storage facilities for temporarily storing sludge materials when they cannot be taken to the landfill. At a minimum, these plans and specifications should include plans, cross-sections, details, and construction specifications for a contractor to construct, complete storage facilities with linings and filtrate collection and removal systems as necessary to maintain the sludge materials in a state which can be later landfilled and which will prevent the release of sludge or filtrate to the environment.

124 Prefinal Design Submittal

The prefinal design submittal should include copies of final plans, specifications, and plans for final review by the appropriate agencies. In all respects, these documents should be complete and detailed enough to provide for construction and operation of the landfill site.

125 Prefinal Design Meeting
The prefinal design meeting will be a meeting with EPA, the Respondents, and applicable reviewers to discuss final review comments for the design and to agree upon final modifications. The meeting will be documented by a follow-up letter which approves all final design documents contingent upon inclusion of agreed-upon modifications, if any. Once these modifications have been incorporated, the design will be considered complete and construction and operation may begin.

126 BFP Construction
BFP construction will include the installation of all containment system components, drainage structures, and other design features required to start the first phase of landfill operation. Once these are in-place and approved by the applicable agencies, operation of sludge disposal operations in BFP may begin.

127 blank

128 Waste Piles

129 Preliminary Design
The preliminary design includes developing a draft work plan covering the characterization, removal, consolidation, and capping of seven waste piles identified in the ROD. The plan must provide for compliance with the ARARs described in the ROD. The work plan shall include drainage and erosion control measures for all areas disturbed by this action.

130 Work Plan Meeting
Meeting with EPA and state agencies to review the work plan.

131 Sampling and Analysis Plan
Sampling and Analysis Plan, including a Quality Assurance Project Plan (QAPP), covering field and laboratory work necessary to fully characterize the seven waste piles identified in the ROD. The laboratory analyses shall include particle size distribution, plasticity index, sulfide content, and acid generating potential tests on each pile, as well as other physical or chemical tests necessary to fully characterize each waste pile.

132 Preliminary Disposal Design
Selection of an onsite disposal area into which the waste piles can be consolidated into and capped, and preliminary design of the facility in accordance with the ARARs described in the ROD.

133 Preliminary Design Submittal
Written submittal of the final work plan, sampling and analysis plan, quality assurance project plan, and preliminary design of the disposal area.

134 Preliminary Design Review Meeting
Meeting with EPA and state agencies to review the preliminary design submittal.

135 Final Design
Prefinal and final design activities.

136 Field Testing
Field work necessary to characterize the waste piles, complete the sampling, reconnoiter access, and survey the volumes of the piles, to be conducted in accordance with the final approved sampling and analysis plan, and QAPP.

137 Laboratory Testing
Laboratory testing necessary to complete the sampling and analysis plan and QAPP.

138 Draft Final Work Plan
The Draft Final Work Plan shall include all items addressed by reviewers in the Preliminary Design Review Meeting. Prefinal design shall include plans and specifications for excavation, placement, capping, drainage, erosion control, testing and monitoring.

139 Prefinal Design Submittal
Written submittal of the prefinal design and Draft Final Work Plan.

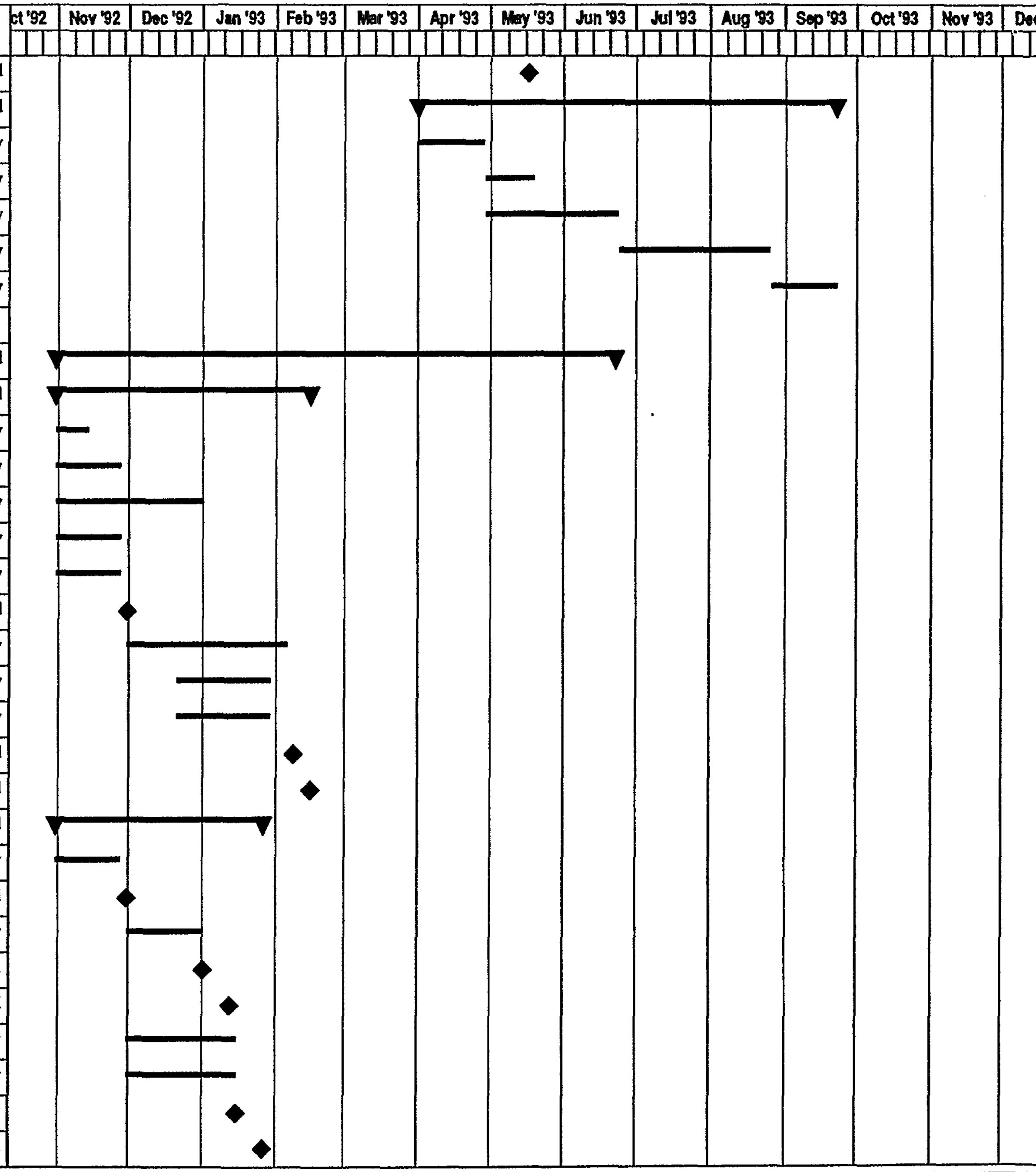
140 Prefinal Design Meeting
Meeting with EPA and state agencies to review the prefinal design.

141 Waste Pile Excavation and Placement
Construction activity to implement the remedial action.

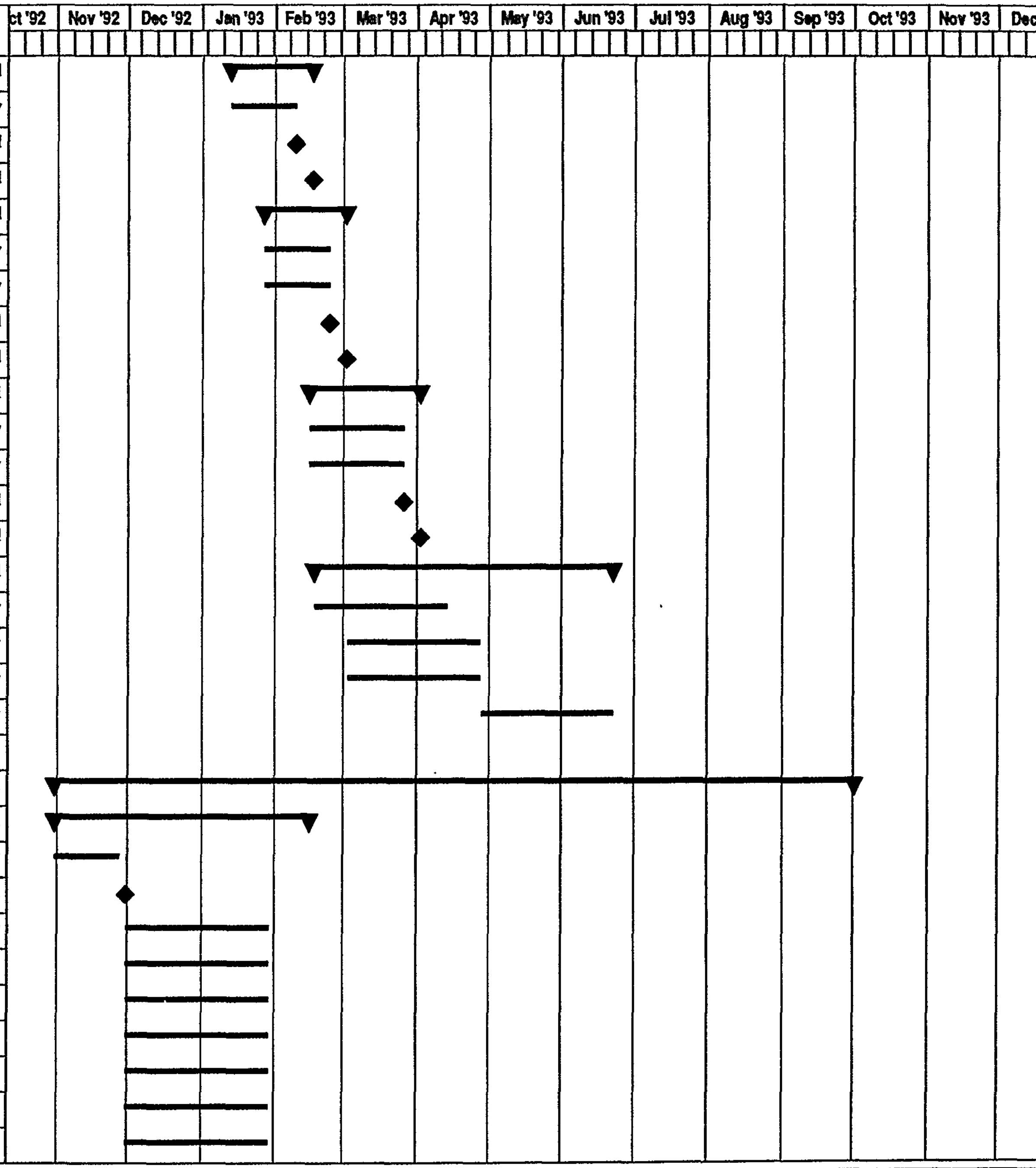
IMM: HDS Plant Construction Schedule Draft Date:10/23/92

ID	Name	Duration	ct '92	Nov '92	Dec '92	Jan '93	Feb '93	Mar '93	Apr '93	May '93	Jun '93	Jul '93	Aug '93	Sep '93	Oct '93	Nov '93	Dec
1	Plant	233d															
2	Plant Preliminary Design	75d															
3	Site Selection	4w															
4	Final Design Criteria	4w															
5	Preliminary I&C Strategy	4w															
6	Preliminary Project Delivery Analysis	4w															
7	Work Plan Meeting	0d															
8	Finalize I&C Strategy	9w															
9	Develop Hydraulic Profile	9w															
10	Select Equipment and Manufacturers	9w															
11	Major Equipment Specifications	9w															
12	Issue P.O.s for Major Equipment	0d															
13	Contingency Plan	9w															
14	Project Delivery Analysis (Draft Final)	9w															
15	Preliminary Design Submittal	0d															
16	Preliminary Design Review Meeting	0d															
17	Plant Final Design	65d															
18	Mechanical	55d															
19	Process, I&C Coordination	11w															
20	Equipment Specifications	11w															
21	Mechanical Drawings	11w															
22	Mechanical Specifications	11w															
23	Electrical	55d															
24	Electrical Facility Plans	11w															
25	Electrical Control Diagrams	11w															
26	Detailed Electrical Specifications	11w															
27	Final Process and Instrumentation	11w															
28	Structural	55d															
29	Structural Plans	11w															
30	Structural Specifications	11w															
31	Prefinal Design Submittal	0d															

ID	Name	Duration
32	Prefinal Design Meeting	0d
33	Plant Construction	125d
34	Initial Site Preparation	4w
35	Final Site Preparation	3w
36	Foundation and Structures	8w
37	Install Equipment	9w
38	Shakedown	4w
39		
40	Civil/Site & Roads	167d
41	Preliminary Civil/Site Design	75d
42	Preliminary Plant Site Plans	2w
43	Site Selection	4w
44	Survey and Mapping	9w
45	Final Design Criteria	4w
46	Preliminary Plant Layout	4w
47	Work Plan Meeting	0d
48	Geotechnical Assessment	10w
49	Preliminary AMD Routing	6w
50	Preliminary Utility Routing	6w
51	Preliminary Design Submittal	0d
52	Preliminary Design Review Meeting	0d
53	Preliminary Road Design	62d
54	Flat Creek Bridge Assessment	4w
55	Work Plan Meeting	0d
56	Flat Creek Bridge Preliminary Design	5w
57	Flat Creek Bridge Submittal	0d
58	Flat Creek Bridge Review Meeting	0d
59	Onsite Roads	7w
60	County Roads	7w
61	Preliminary Road Design Submittal	0d
62	Preliminary Road Design Review Meeting	0d

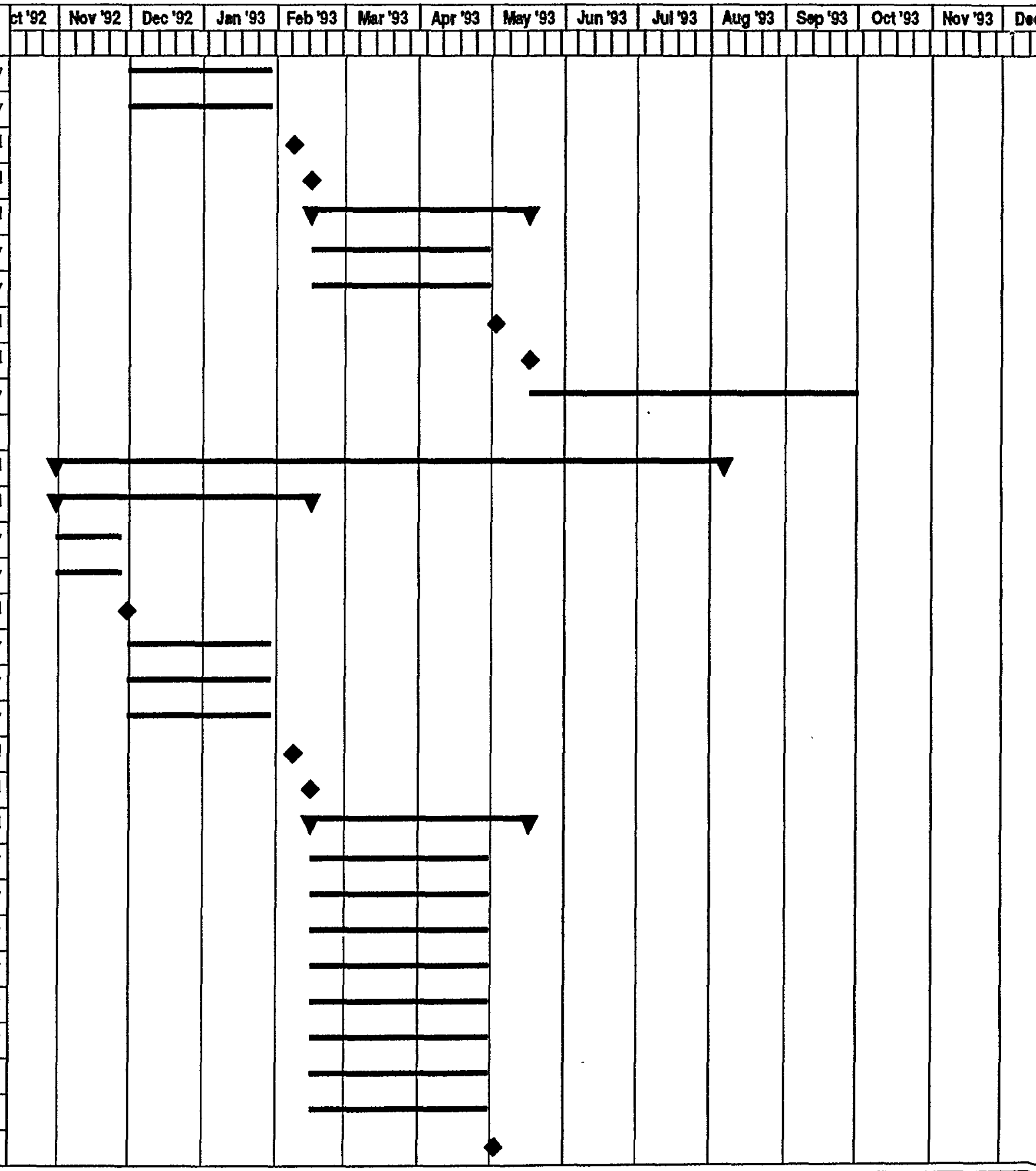


ID	Name	Duration
63	Flat Creek Bridge Final Design	25d
64	Flat Creek Bridge	4w
65	Prefinal Design Submittal	0d
66	Prefinal Design Meeting	0d
67	Roads Final Design	25d
68	County Roads	4w
69	Onsite Roads	4w
70	Prefinal Design Submittal	0d
71	Prefinal Design Meeting	0d
72	Civil/Site Final Design	35d
73	Civil/Site Plans	6w
74	Civil/Site Specifications	6w
75	Prefinal Design Submittal	0d
76	Prefinal Design Meeting	0d
77	Road Construction	90d
78	Flat Creek Bridge Construction	8w
79	County Road Construction	8w
80	Onsite Road Construction - Phase 1	8w
81	Onsite Road Construction - Phase 2	8w
82		
83	AMD Conveyance and Utilities	240d
84	Preliminary design	75d
85	Final Design Criteria	4w
86	Work Plan Meeting	0d
87	Pipeline Route Selection	9w
88	Pump Station Locations	9w
89	Electrical Utility Locations	9w
90	Pump Station Component Layout	9w
91	Pipeline Appurtenances	9w
92	Hydraulic Analysis	9w
93	Select Equipment	9w



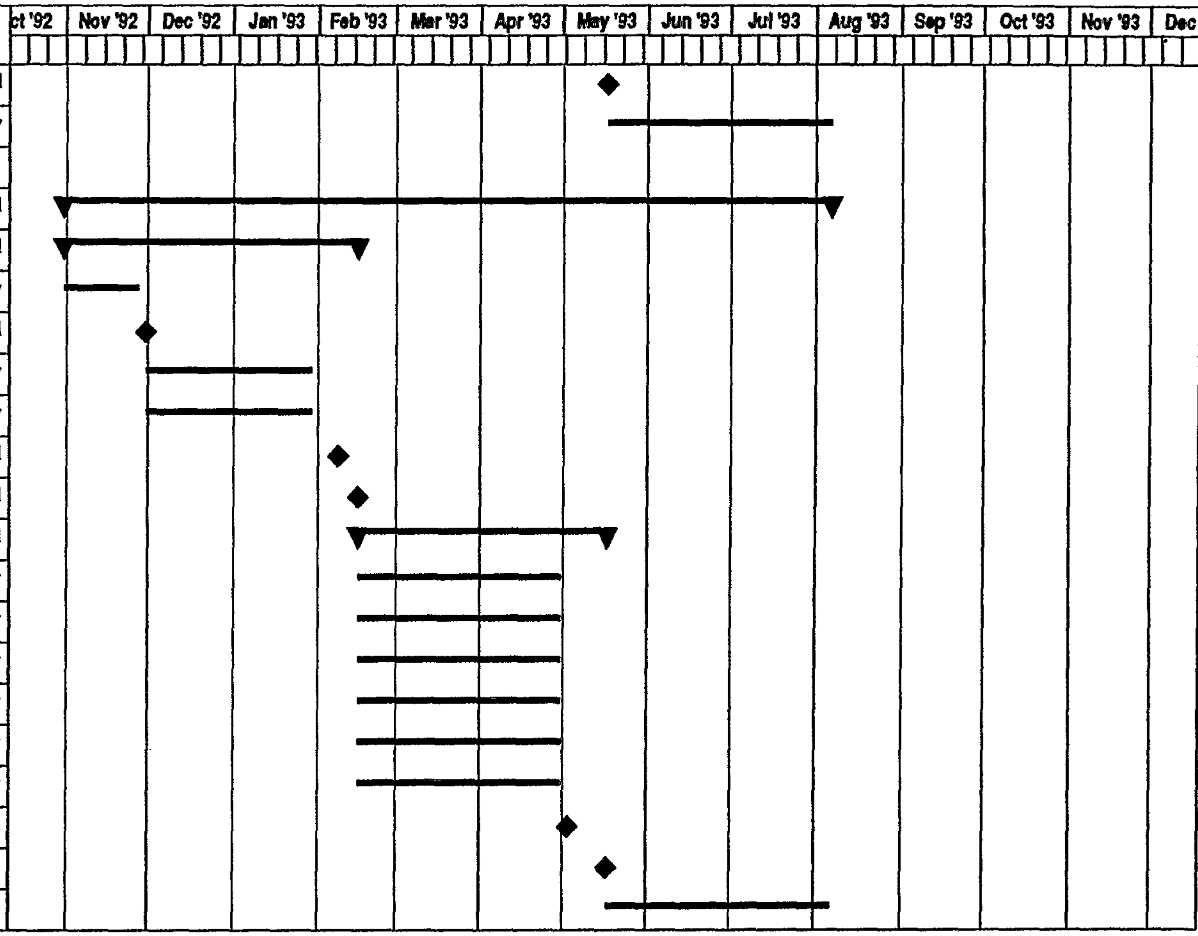
IMM: HDS Plant Construction Schedule Draft Date:10/23/92

ID	Name	Duration
94	Surge Analysis	9w
95	Corrosion Design	9w
96	Preliminary Design Submittal	0d
97	Preliminary Design Review Meeting	0d
98	Final Design	65d
99	Plans	11w
100	Specifications	11w
101	Prefinal Design Submittal	0d
102	Prefinal Design Meeting	0d
103	AMD & Utility Construction	20w
104		
105	BFP Improvements	200d
106	Preliminary Design	75d
107	Final Design Criteria	4w
108	Initial Site Layout	4w
109	Work Plan Meeting	0d
110	Preliminary Site Layout	9w
111	Preliminary Operational Plan	9w
112	Preliminary Monitoring Plan	9w
113	Preliminary Design Submittal	0d
114	Preliminary Design Review Meeting	0d
115	Final Design	65d
116	Liner and Filtrate System Design	11w
117	Ore Body Segregation Design	11w
118	Precipitation and Drainage Control	11w
119	Filtrate Discharge System	11w
120	Final Operational Plan	11w
121	Final Monitoring Plan	11w
122	Discharge Conveyor Design	11w
123	Sludge Storage Design	11w
124	Prefinal Design Submittal	0d



IMM: HDS Plant Construction Schedule Draft Date:10/23/92

ID	Name	Duration
125	Prefinal Design Meeting	0d
126	BFP Construction	12w
127		
128	Waste Piles	200d
129	Preliminary Design	75d
130	Initial Excavation and Disposal Plan	4w
131	Work Plan Meeting	0d
132	Sampling and Analysis Plan	9w
133	Preliminary Disposal Design	9w
134	Preliminary Design Submittal	0d
135	Preliminary Design Review Meeting	0d
136	Final Design	65d
137	Field Testing	11w
138	Laboratory Testing	11w
139	Excavation	11w
140	Drainage and Erosion Control	11w
141	Capping	11w
142	Plans and Specifications	11w
143	Prefinal Design Submittal	0d
144	Prefinal Design Meeting	0d
145	Waste Piles Excavation and Placement	12w



ATTACHMENT C

WET LANDFILL CONCEPT

PREPARED BY: Edward R. Underwood/Reston

DATE: October 26, 1992

SUBJECT: Wet Landfill Concept for Sludge Disposal
at Brick Flat Pit
Iron Mountain Mine

PROJECT: RDD69017.TP.01a

Introduction

This memorandum presents design concerns and conceptual design details for lining Brick Flat Pit for sludge disposal, and for diverting and segregating acid seepage from existing pyrite at the western end of the pit, diverting surface water and rain water in the pit, and collecting filtrate from the treatment sludge. It is based on:

- Treatment Alternative P1-B, Treatment of Portal Flows with a Lime/Sulfide Neutralization High Density Sludge (HDS) Process for sustained elevated flows from Richmond and Lawson portals and Simple Mix Lime Neutralization Process for excess flows

- Operation of the treatment plant above the eastern end of Brick Flat Pit with sludge discharge directly to Brick Flat Pit and with dewatering occurring within Brick Flat Pit

- Applicable California Group B design requirements as specified in the current EPA Record of Decision, including:

    - Prohibition of construction in a Holocene fault area

    - Flood protection from a 100-year peak streamflow

    - Precipitation and drainage controls for a 10-year, 24-hour design storm

    - Seismic safety applicable to construction projects in general

    - Compliance with the State of California statutes and regulations pertaining to construction of dams

- Specific concerns raised by internal and external reviewers of the feasibility study, such as:

- The need to minimize seepage of filtrate into the subsurface of the pit

- The need to segregate acid seepage from existing pyrite within Brick Flat Pit from filtrate to prevent clogging of the filtrate collection/removal system and to prevent recontamination of filtrate with acid and metals

- The need to provide for long-term collection of filtrate from the sludge

- The need to maximize the disposal space in the pit and to minimize initial and annual construction costs

The following discussion presents design concepts and requirements for developing Brick Flat Pit as a wet landfill site. It is supplemented by Figures TP.01a-1, -2, and -3, which illustrate these concepts and their interrelationships.

Design Concepts and Requirements

Site Operation and Drainage

Operation of the Brick Flat Pit site as a wet landfill would include the direct discharge of treatment sludge from a treatment plant located above the pit, dewatering of the sludges, and removal of filtrate water from the bottom and surface of the sludge. This form of operation would allow very little access into the disposal area for construction and maintenance without the need for some form of reinforced access roads and trails across the dried sludge deposits. Even this form of access would likely be limited to dry summer months when rainfall and treatment rates are at their lowest annual values.

Experience with wet tailings sites with similar conditions suggests that the disposal process would require the development and operation of Brick Flat Pit as a dam and impoundment with adequate capacity for normal sludge settling and disposal requirements and storage for the appropriate design storm.

The height of the dam and impounding capacity required to provide adequate sludge and storm storage would require that the site be developed and designed to substantively comply with the State of California Department of Water Resources "Statutes and Regulations Pertaining to Supervision of Dams and Reservoirs, 1992."

The dam would be constructed with its upstream toe at the northern end of the narrow cut leading into Brick Flat Pit. This configuration minimizes the width of the dam while maximizing the impounding capacity of Brick Flat Pit. The dam would be constructed of native soil materials and would be constructed to approximate Elevation 3300 using downstream construction techniques. With these techniques, the

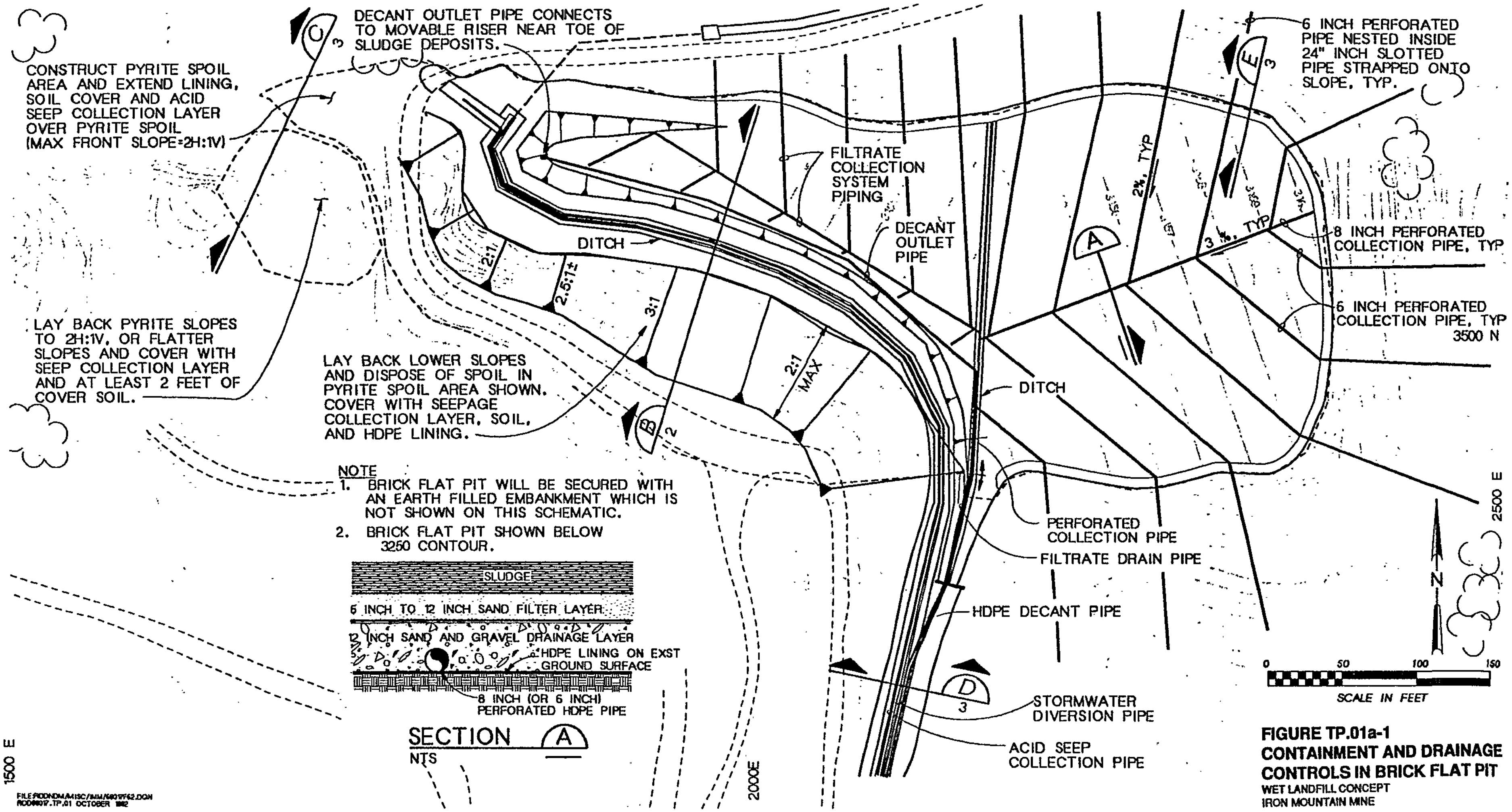
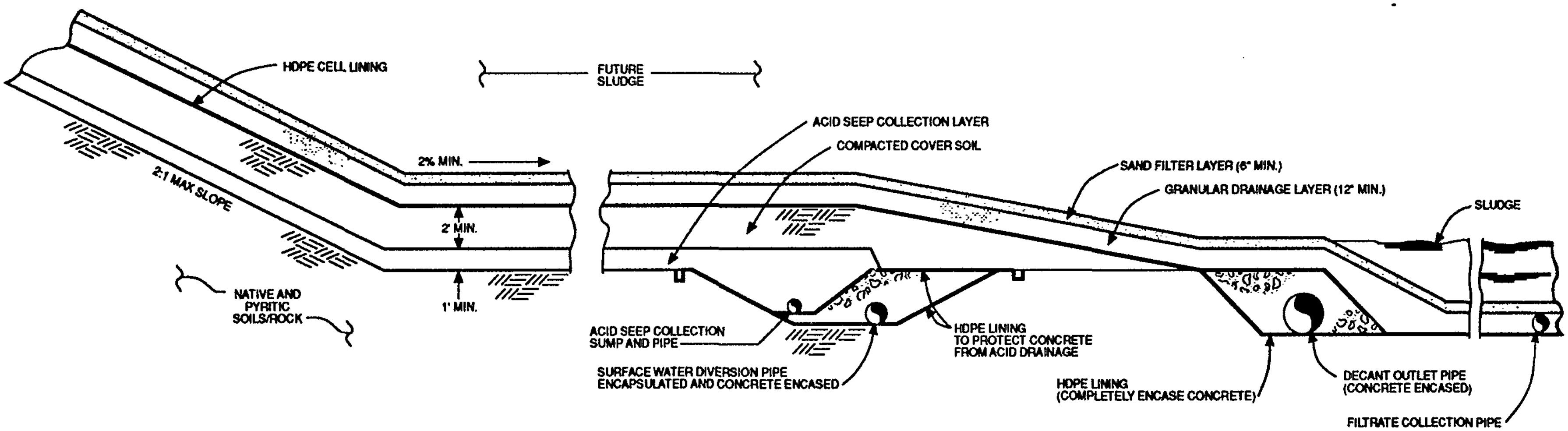


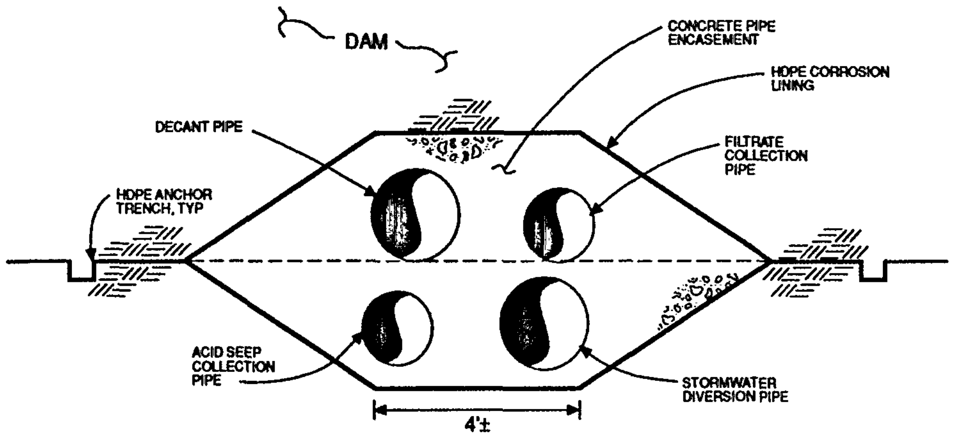
FIGURE TP.01a-1
CONTAINMENT AND DRAINAGE CONTROLS IN BRICK FLAT PIT
WET LANDFILL CONCEPT
IRON MOUNTAIN MINE



SEEPAGE COLLECTION, CONTAINMENT SYSTEM, AND PIPING SECTION B/1
(WESTERN END OF PIT)

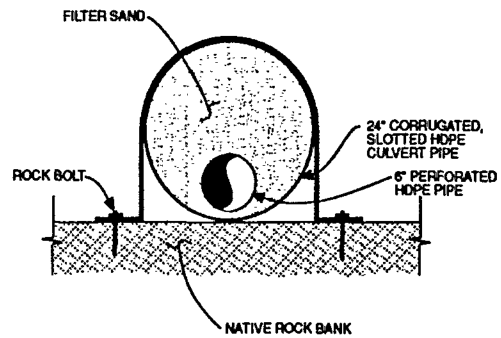
USR5/PROJECTS/S2/RDD/RDD6
RDD69017.TP.01/IMM/SB-a/9-1992

FIGURE TP.01a-2
SECTION B
WET LANDFILL CONCEPT
IRON MOUNTAIN MINE

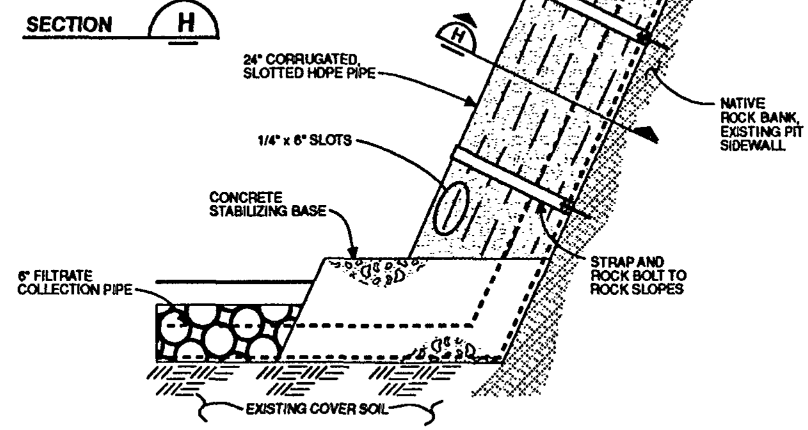


PIPE PENETRATION BENEATH DAM
(CONSTRUCTED IN EXISTING DRAINAGE CHANNEL)

SECTION D
NTS 1

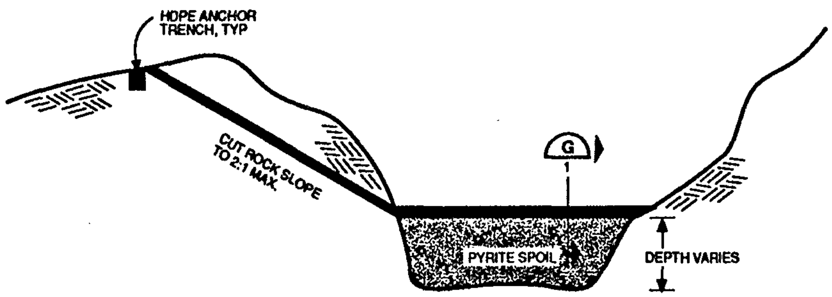


SECTION H



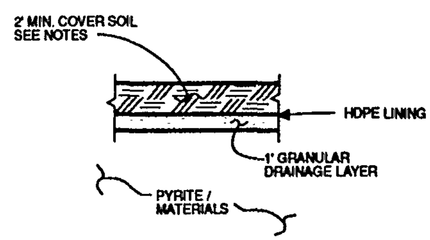
CONCEPTUAL SIDESLOPE DRAINAGE ZONE

SECTION E
NTS 1



PYRITE SPOIL/SLOPE COVER CONFIGURATION

SECTION C
NTS 1



SECTION G
NTS

NOTES: 1. COVER SOIL PLACEMENT ON SLOPES WILL REQUIRE THE USE OF GEOGRID MATERIALS BETWEEN THE HDPE LINING AND THE COVER SOIL.

2. UPPER 6" OF COVER SOIL SHOULD CONSIST OF ROCK OR GRAVEL SOILS TO PROVIDE EROSION PROTECTION TO THE COVER.

USR5/PROJECTS/S2/RDD/RDD6
RDD69017.TP.01/IMM/MS-a/9-1992

FIGURE TP.01a-3
MISCELLANEOUS SECTIONS
WET LANDFILL CONCEPT
IRON MOUNTAIN MINE

downstream toe would move progressively downstream as the height of the dam increases. In addition, a reinforced earth dike would be constructed within the roadway cut at the northeastern corner of the pit between Elevations 3260 and 3300. Both the main dam and the dike in the northeastern corner would be raised above Elevation 3300 using upstream construction techniques. These techniques, which are accepted practice for tailings dam construction, consist of constructing a series of interlocking dikes which progress in an upstream manner as the sludge level increases. Practical dike heights typically range from 5 to 15 feet.

The dam would be staged such that contruction would occur in three to four increments, which would allow dam construction costs to be spread out over the life of the operation. The height of the dam at each stage would be selected to provide full design storm storage above the proposed sludge level for that stage. Full storm storage is deemed to be more appropriate than the use of channel spillways because of the topography of the vicinity of the pit, lack of adequate discharge locations for large outlet flows, and difficulties in moving spillways during staged construction, which will be required during the life of the impoundment.

A decant pipe or floating pump system would be required to release stored storm water from the impoundment within a reasonable time. The decant pipe or floating pump system must also serve as a continuous release for treated water once the sludge has settled out. It is recommended that a pipe decant system be used since it would operate much more independently and with significantly less maintenance than does a pump system. Since sludge is currently expected to be discharged into the eastern end of the pit, the major portion of the surface water, and thus the decant pipe, would be located in the western end of the pit. The decant pipe should be designed such that it is supported by the pit sidewalls and encased along its entire length to prevent flotation. As the impoundment level rises, the decant pipe would be extended in workable sections. The conceptual location and configuration of the decant pipe across the pit floor are shown on Figures TP.01a-1 and -2.

Although the wet landfill site would be designed and maintained as a dam, it should be operated in a manner in which the amount of surface water within the impoundment is minimized through continuous decanting. This should be done to minimize the potential for releasing water into the subsurface, especially along the unlined sidewalls. Although the site would be a closed basin within which much rainfall would collect, there are several means by which the total amount of normal rainfall runoff from the watershed can and should be diverted around the impoundment. These include:

- Continuous operation and maintenance of diversion ditches and structures which previously were installed above the pit

- Collection of drainage from the ditchline along the road down the north wall of the site in a pipe which will divert it beneath the impoundment and dam (This diversion pipe, whose location and conceptual details are shown on Figures TP.01a-1, -2, and -3, would be designed to handle storm flows equivalent to at least a 10-year, 24-hour design storm. It would be extended up the road in workable segments as the impoundment level rises.)

- Improvement of existing roadway and bench ditches above the pit, where possible, to divert surface water around the impoundment (These should be upgraded for at least a 10-year, 24-hour storm event.)

Containment System

The containment system for Brick Flat Pit must minimize the amount of water which would seep into the mountain and mines below. This was a major concern of the State in that the State perceives a problem of creating more water to treat over the long term. In addition, the containment system must prevent liquids from acid-producing pyrite bodies in the west end of the pit from contacting the sludge and filtrate. This is important for purposes of preventing release of metals from the sludge and preventing the clogging of the filtrate collection system by precipitates where acid and basic waters come together.

The containment system shown on the conceptual design drawings (Figures TP.01a-1, -2, and -3) consists of a high-density polyethylene (HDPE) lining over the entire floor area, approximately 2.4 acres, which was covered and capped with a synthetic membrane, plus approximately 0.9 acre along the western end of the pit, where exposed pyrite slopes to the first bench would be flattened to 2H:1V, or flatter, and would be covered by a granular seepage collection layer, a soil cover layer, and an HDPE lining to segregate them from sludge or filtrate. The HDPE lining would in turn be covered by the filtrate collection layer. Geogrid materials and textured lining materials may be necessary in this area to allow the drainage layer to stay on the 2H:1V slopes. The conceptual configurations of the containment system in these areas are shown on Sections A and B in the conceptual design drawings.

The pyrite slope and spoil area above the first bench, as illustrated in Section C on Figure TP.01a-3, would be of similar configuration and design, except that the HDPE lining would be installed beneath the soil cover, and the upper 6 inches of the soil cover would consist of rock or gravel erosion protection. This would extend the total lined area to approximately 4.5 acres. The lining is proposed beneath the soil cover in this case since the slope may be exposed and subject to mechanical damage for some time before it is covered with sludge.

Acid drainage from pyrite and fill areas would be collected in a trench beneath the HDPE lining system and would be carried by a concrete-encased HDPE pipe below the dam to a sump where it can be pumped to the treatment plant for treatment. Details of this acid seepage collection and removal system are shown in Sections B and D on Figures TP.01a-2 and -3.

The remaining pit sidewalls would not be lined due to their steep and irregular side-slopes. The option of constructing berms along these slopes has been deleted because of:

- Leakage is expected to decrease linearly with applied hydraulic head at higher elevations along the pit sidewall. Minor amounts of leakage are therefore predicted from the overall sideslope area. Due to the relatively high cost of lining the pit sidewall, it may be more economical to just collect and treat that portion of the leakage that finds its way into the underlying Richmond Mine workings.

- The volume of the pit, which would be severely impacted by constructing even short barriers

- The probability that sludge materials would likely fill most surficial fractures, thus decreasing the permeability and water flow into deeper pathways

However, sideslope drainage zones, as discussed in the following section, have been included in the conceptual design to collect horizontal flows in the sludge and decrease the amount of water which is available for infiltration into the sidewalls.

Filtrate Collection System

Conceptual filtrate collection system components are shown on Sections A, B, E, and H in Figures TP.01a-1, -2, and -3. They consist of:

- A 12-inch-minimum-thickness sand and gravel drainage layer with a system of 6-inch- to 8-inch-diameter perforated HDPE collection pipes and a 6-inch-minimum-thickness sand filter layer on the floor of the pit

- A 12-inch-minimum-thickness sand and gravel drainage layer with a 6-inch-minimum-thickness sand filter layer on the covered pyrite slopes to the first bench on the western end of the pit

- A series of individual drainage zones up the pit sideslopes, each consisting of 6-inch-diameter perforated HDPE pipe nested inside a 24-inch-diameter slotted HDPE culvert pipe with the annulus filled with filter sand

The conceptual filtrate collection layer consists of natural drainage and filter materials which have been sized to conform with gypsum gradations found in the literature. Gypsum gradations were used since gypsum from sulfuric acid neutralization with lime appears to have similar properties and gradations as the sludge. On the basis of this information, preliminary filter computations suggest that Class 1, Type A, Permeable Material in Paragraph 68-1.025 of the 1992 Caltrans Standard Specifications may meet the requirements of the sand and gravel drainage layer materials. These computations also suggest that Sand Bedding Material meeting the requirements of Paragraph 19-3.025 of the same specifications may be appropriate sand filter material. Final design, however, should include gradation testing of actual HDS and Simple Mix sludge materials likely to be disposed of in the impoundment and confirmation that these available materials meet the standard filter criteria.

Should it be found that available natural filter and drainage materials do not meet standard filter criteria, synthetic filter materials should be reviewed for use. These materials, however, should be considered and specified carefully since there is currently some concern within the engineering community about their potential to clog and form a barrier to drainage rather than a filter.

Special Considerations

Special design and construction considerations must be included in design of the impoundment and containment systems to account for special site conditions. These considerations should include, but not be limited to:

- Construction and seepage controls necessary to account for existing fractures, joints, and vertical surfaces which will form the abutments of the dam

- Access to the dam for construction, inspection, and maintenance

- Modifications to normal anchoring methods for the geomembrane lining system, such as battens, rock bolts, anchors, etc., to prevent leakage at these parts and as a result of difficulties in constructing conventional anchor trenches along rock slopes

- Special foundation and backfill gradation requirements, or geotextile padding layers as appropriate, to protect the geomembrane lining system from potentially abrasive or sharp materials below or above it

- Selection and protection of all construction materials to accommodate expected chemical, UV-exposure, and loading conditions at the site (This has conceptually been included with the use of HDPE lining and pipe materials and encapsulation of all concrete in an HDPE wrap. Additional work must be done for selecting and protecting other construction materials such as metals, plastics, aggregates, and geotextiles.)

- Preparation of details which will minimize the potential for clogging of the acid seep collection and removal system piping with iron precipitates (This has reportedly been done simply at Appalachian coal mine sites by having an upturned elbow at the outlet end which keeps the end of the pipe flooded, thus preventing the entrance of oxygen, which is required to cause iron precipitation.)

ATTACHMENT D

DRY LANDFILL CONCEPT

PREPARED BY: Edward R. Underwood/Reston

DATE: October 26, 1992

SUBJECT: Dry Landfill Concept for Sludge Disposal at Brick Flat Pit Iron Mountain Mine

PROJECT: RDD69017.TP.01b

Introduction

This memorandum presents design concerns and conceptual design details for lining Brick Flat Pit for sludge disposal, and for diverting and segregating acid seepage from existing pyrite at the western end of the pit, diverting surface water and rain water in the pit, and collecting filtrate from the treatment sludge. It is based on:

- Treatment Alternative P1-B, Treatment of all Richmond and Lawson Portal Flows with a Lime/Sulfide Neutralization High Density Sludge (HDS) Process
- Operation of the treatment plant at a location down the mountain from Brick Flat Pit for dry landfill disposal
- Applicable California Group B design requirements as specified in the current EPA Record of Decision, including:
  - Prohibition of construction in a Holocene fault area
  - Flood protection from a 100-year peak streamflow
  - Precipitation and drainage controls for a 10-year, 24-hour design storm
  - Seismic safety applicable to construction projects in general
- Specific concerns raised by internal and external reviewers of the feasibility study, such as:
  - The need to minimize seepage of filtrate into the subsurface of the pit

- The need to segregate acid seepage from existing pyrite within Brick Flat Pit from filtrate to prevent clogging of the filtrate collection/removal system and to prevent recontamination of filtrate with acid and metals

- The need to provide for long-term collection of filtrate from the sludge

- The need to maximize the disposal space in the pit and to minimize initial and annual construction costs

The following discussion presents design concepts and requirements for developing Brick Flat Pit as a dry landfill site. It is supplemented by Figures TP.01b-1, -2, and -3, which illustrate these concepts and their relationships with each other.

Design Concepts and Requirements

Site Operation and Drainage

Operation of the Brick Flat Pit site as a dry landfill would be similar to that of a solid waste or mining waste landfill. Development of a dry landfill would be started by installing initial surface-water diversion, orebody segregation, lining, and filtrate collection components similar to those which would be used for a wet landfill. The major differences for a dry landfill include the deletion of a decant pipe and sidehill filtrate collection pipes, which are neither necessary nor applicable for a dry landfill.

Initial surface-water diversion facilities are critical to successful construction and operation of the landfill, especially since landfill operation is scheduled to be in the fall of the year. As a result, the following controls must be in place before landfill operations may begin:

- Continuous operation and maintenance of diversion ditches and structures which previously were installed above the pit

- Collection of drainage from the ditchline along the road down the north wall of the site in a pipe which will divert it beneath the toe of the landfill (This diversion pipe, whose location and conceptual details are shown on Figures TP.01-b-1, -2, and -3, would be designed to handle storm flows equivalent to at least a 10-year, 24-hour design storm. It would be extended up the road as the impoundment level rises.)

- Improvement of existing roadway and bench ditches above the pit, where possible, to divert surface water around the landfill area (These ditches should be upgraded for a 10-year, 24-hour storm event.)

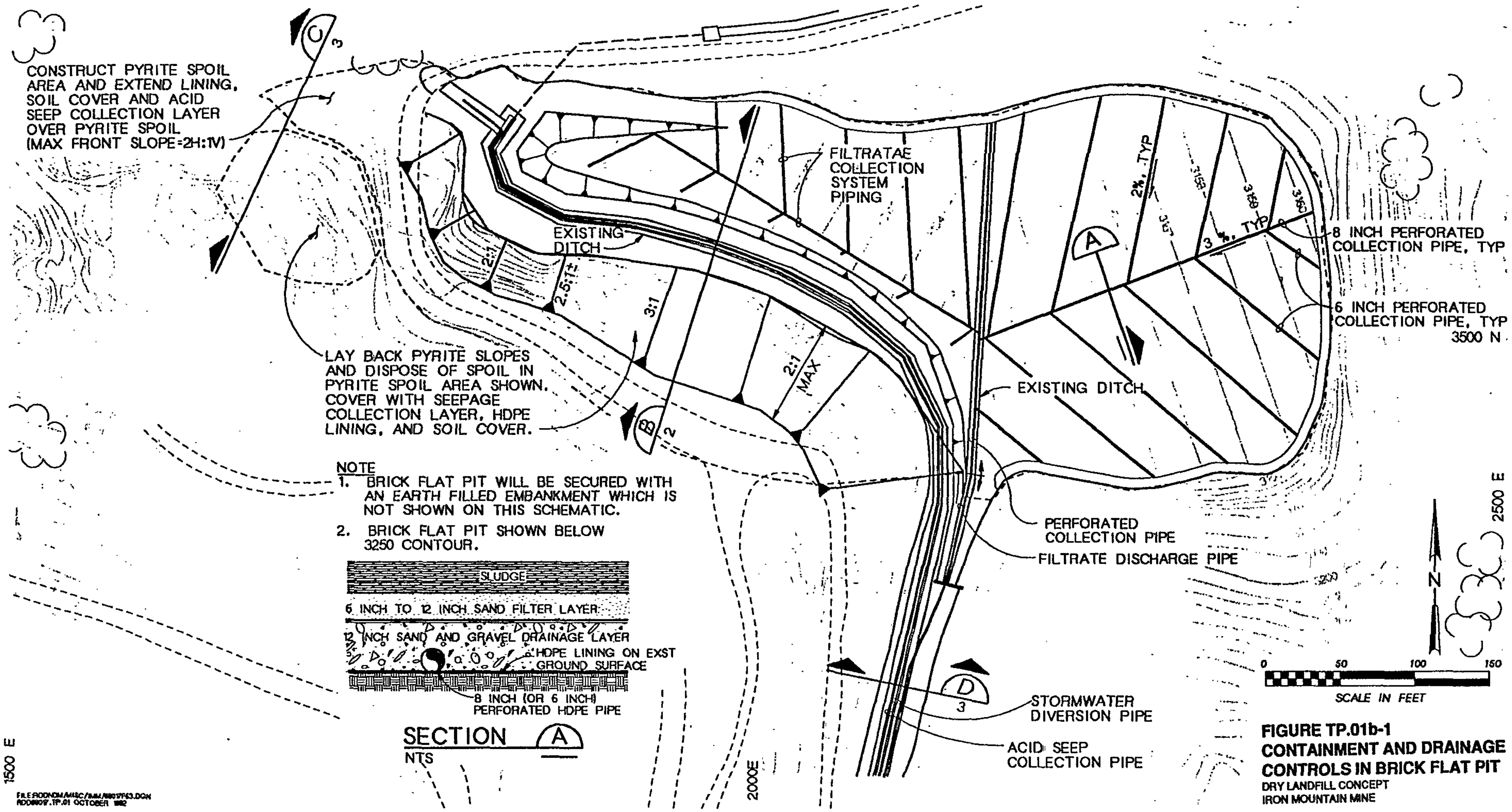
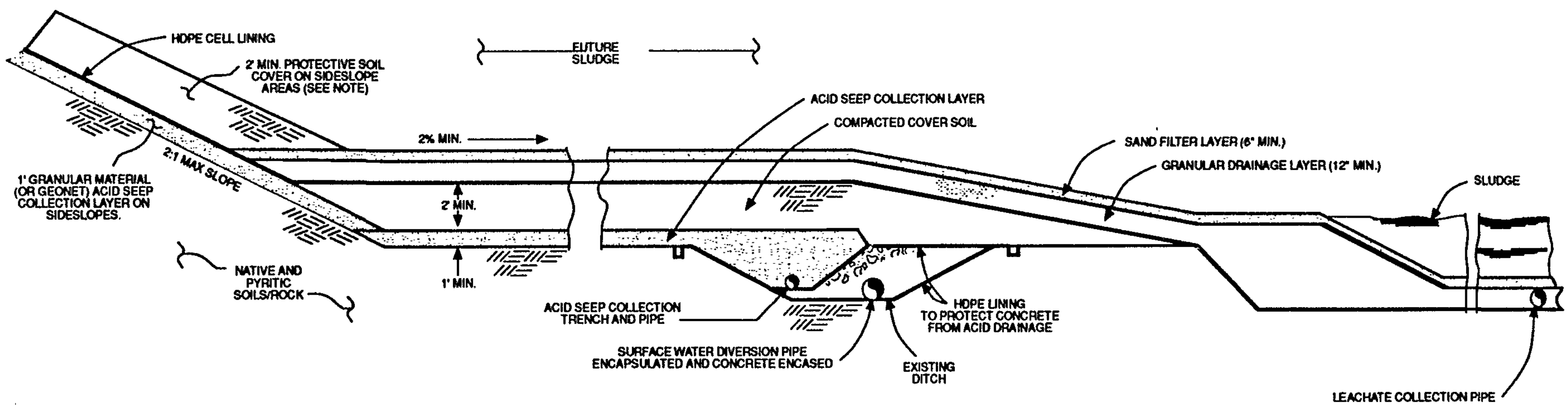


FIGURE TP.01b-1
CONTAINMENT AND DRAINAGE CONTROLS IN BRICK FLAT PIT
DRY LANDFILL CONCEPT
IRON MOUNTAIN MINE

FILE:RODNOM/MISC/MM/RM01F63.DGN
RODM007.TP.01 OCTOBER 1992



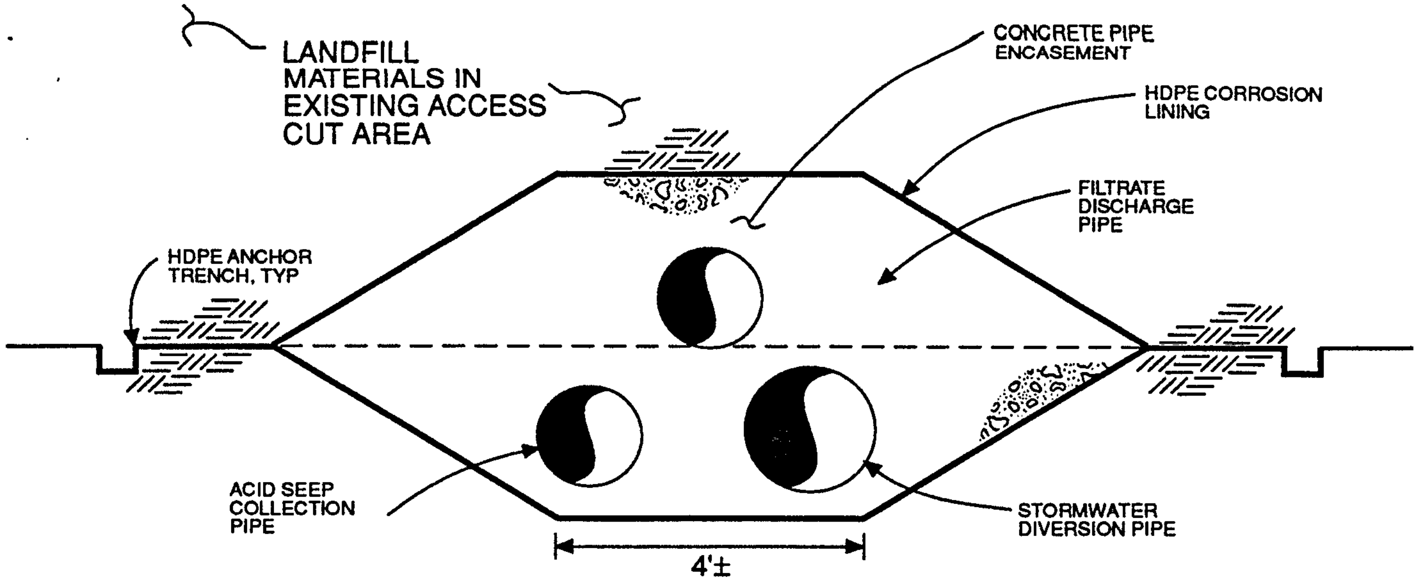
SEEPAGE COLLECTION, CONTAINMENT SYSTEM, AND PIPING SECTION B/1
(WESTERN END OF PIT)

0 5' 10'
SCALE IN FEET

NOTE: THE UPPER 6 INCHES OF THE PROTECTIVE SOIL LAYER SHOULD CONSIST OF GRAVEL OR ROCK MATERIALS TO MINIMIZE EROSION UNTIL THE SLOPE IS COVERED BY SLUDGE MATERIALS.

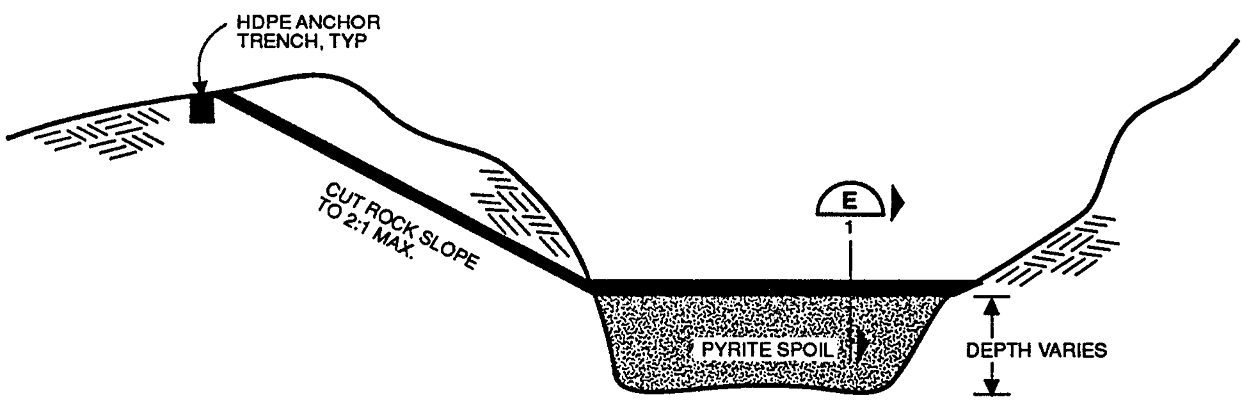
USR5/PROJECTS/S2/RDD/RDD6
RDD69017.TP.01/IMM/SB-b/9-1992

FIGURE TP.01b-2
SECTION B
DRY LANDFILL CONCEPT
IRON MOUNTAIN MINE



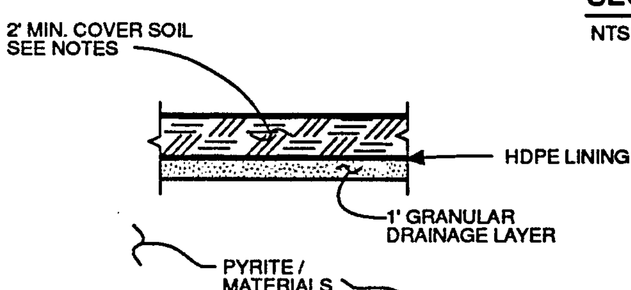
PIPE PENETRATION BENEATH LANDFILL TOE AREA
(CONSTRUCTED IN EXISTING DRAINAGE CHANNEL)

SECTION D
NTS 1



PYRITE SPOIL/SLOPE COVER CONFIGURATION

SECTION C
NTS 1



SECTION E
NTS

NOTES: 1. COVER SOIL PLACEMENT ON SLOPES WILL REQUIRE THE USE OF GEOGRID MATERIALS BETWEEN THE HDPE LINING AND THE COVER SOIL.

2. UPPER 6" OF COVER SOIL SHOULD CONSIST OF ROCK OR GRAVEL SOILS TO PROVIDE EROSION PROTECTION TO THE COVER.

USR5/PROJECTS/S2/RDD/RDD6
RDD69017.TP.01/IMM/MS-b/9-1992

FIGURE TP.01b-3
MISCELLANEOUS SECTIONS
DRY LANDFILL CONCEPT
IRON MOUNTAIN MINE

The landfill would be raised beginning at the base of Brick Flat Pit and expanding upward in progressive lifts extending across the landfill footprint. Drainage around the fill would be provided by the diversion pipe which controls drainage from the road on the north slope and soil-covered drainage ditches around the perimeter. Drainage controls would be extended and relocated as necessary during the summer months to conform with the vertical rise in sludge. These ditches would be sized and stabilized as necessary to prevent overflow and erosion during at least a 10-year, 24-hour design storm.

During the dry months of the year, sludge materials would enter the site from the existing road into the site and would be deposited, spread, and compacted in a manner similar to that of a normal fill. Placement would generally begin at the upper part of the pit and progress toward the toe area at the southern end. This method of placement would promote continuous drainage and would prevent the impoundment of water behind the fill. Lift thicknesses would depend upon the operational nature of the sludge materials, an unknown factor at this time. As a result, spreading and compaction operations could include:

- Spreading and compaction in 12- to 24-inch lifts using normal bulldozers and compaction equipment if the materials enter the site as soil materials at moisture contents which will allow normal spreading and compaction

- Placing the sludge in small piles or windrows where they will be allowed to gravity-drain or air-dry sufficiently for spreading, working, and compaction to an acceptable lift thickness using wide-tracked bulldozers or similar equipment

Considering the nature of the sludge materials and the lack of rainfall in the summer months, it is unlikely that significant cover soil would be required on the fill surface unless there is a potential dust problem. Should temporary cover be necessary, it could be removed and reused to a significant extent as the fill rises lift by lift.

Winter disposal operations at Brick Flat Pit could be significantly different due to the larger quantities, higher moisture contents, and wet weather conditions. These operations could include one or a combination of the following methods of operations:

- Normal summerlike operations if the nature and volume of sludge is still manageable during the winter months

- Placement of wet sludge into a diked wet weather operations area during periods when it cannot be dried, spread, and compacted effectively

- Temporary shutdown of Brick Flat Pit, temporary stockpiling of sludges near the treatment plant, and removal of these sludges to Brick Flat Pit when they can be spread and compacted

A wet weather operations area would be constructed each fall in the eastern end of the pit, where cells of wet sludges would not affect the stability of the main fill. The area would be diked with native soil materials to form a temporary containment area. Wet or semiliquid sludges would be dumped in this area until normal sludge disposal conditions return. The dike would be maintained to the minimum height necessary to contain expected sludge volumes and would be provided with a notch to prevent the impoundment of significant amounts of rainwater. A sump area or similar provisions would be provided to prevent the release of sludge and sediment.

As dry conditions again occur, the winter weather operations area would be closed by spreading, leveling, and compacting dumped sludges, where possible, to provide a firm base and placement of dry sludge materials above them, or by backfilling the winter area with native soil or dry sludge materials to form a raft-like zone over which dry sludge materials may be placed. Sludge volumes may, however, be such that a wet weather operations area can remain open for more than one year. In this case, it would only be leveled or backfilled to the extent necessary to prevent the ponding of water and provide improvements necessary for later use.

The front face would be graded to an average slope of 4H:1V, which would likely consist of 3H:1V slopes with benches. Flatter slopes may be necessary for final slopes if flexible membrane linings are required in the cap system. Permanent or semipermanent soil cover and abutment ditches designed and protected for at least a 10-year, 24-hour design storm would be installed as the landfill rises in elevation. Soil cover and abutment ditches would be stabilized as necessary to prevent erosion under design storm conditions. The top of the soil cover would be mounded to form a berm to prevent the spillover of sludge materials or drainage over the front slope. The abutment ditches would be periodically extended to collect drainage from the perimeter ditches around the landfill area.

The dry landfill would be operated in phases. Phase I would provide dry sludge placement to approximate Elevation 3190, the current crest of the entrance road into Brick Flat Pit. Available storage capacity and operational life to this elevation is approximately 183,000 cubic yards and 5.5 years, respectively. These projections are based on an estimated HDS production rate of 30,000 cubic yards per year and a utilization ratio of 90 percent (90 percent sludge and 10 percent fill).

Phase II would extend the fill to approximate Elevation 3230 and would extend the landfill volume and life to approximately 448,000 cubic yards and 13 years, respectively. It would be developed in much the same manner as Phase I and would maintain access to the fill and adjoining areas by way of the existing access road into BFP. There would, however, be some access road extension as the western edge of the fill extends above Elevation 3190.

Phase III of Brick Flat Pit development could be done in two different ways. The first alternative includes extension of the Phase I and II fills upward to the maximum elevation which the 4H:1V slopes will allow, approximate Elevation 3310. This alternative extends the volume and life to approximately 868,000 cubic yards and 25.5

years. It maintains access to the fill and adjacent areas by existing access roads, thus deferring major road-building efforts at least 25 years. Since development of Phase III in this manner presents an apparent volume shortfall for the first 30 years, it must be followed by a Phase IV fill which would begin downstream of and extend over the main fill. Phase IV would require the construction of a major access road since it would quickly cut off access by the existing entrance road.

The second alternative for extending Phase III includes construction of a downstream berm as necessary to maximize the volume of Brick Flat Pit and then extend the fill lift by lift above the Phase II elevation. Since this would quickly cut off access by the existing entrance road, a new access road would have to be constructed into Brick Flat Pit. The second alternative for Phase III development is probably the most efficient solution. It provides less reconstruction of ditches and slopes, less overall cover and backfill, and a much more efficient operating area throughout the entire life cycle of Brick Flat Pit. It also maintains a lower profile and fewer slope maintenance requirements than does the first alternative.

Containment System

The containment system for Brick Flat Pit must address the amount of water which would seep into the mountain and mines below. This was a major concern of the State in that the State perceives a problem of creating more water to treat over the long term. In addition, the containment system must prevent liquids from acid-producing pyrite bodies in the west end of the pit from contacting the sludge and filtrate. This is important for purposes of preventing release of metals from the sludge and preventing the clogging of the filtrate collection system by precipitates where acid and basic waters come together.

The containment system shown on the conceptual design drawings consists of a high-density polyethylene (HDPE) lining over the entire floor area, approximately 2.4 acres, which was covered and capped with a synthetic membrane, plus approximately 0.9 acre along the western end of the pit, where exposed pyrite slopes to the first bench would be flattened to 2H:1V, or flatter, and would be covered by a granular seepage collection layer, a soil cover layer, and an HDPE lining to segregate them from sludge or filtrate. The HDPE lining would in turn be covered by a minimum of 2 feet of protective soil cover, of which the upper 6 inches should include gravel or rock materials to minimize erosion. Section E on Figure TP.01b-3 presents a cross-section showing the drainage, lining, and protective soil cover layers. Geogrid materials and textured lining materials may be necessary in this area to allow the drainage layer to stay on the 2H:1V slopes. The conceptual configurations of the containment system in these areas are shown on Sections A and B in Figures TP.01b-1 and -2.

The pyrite slope and spoil area above the first bench, as illustrated in Sections C and E on Figure TP.01b-3, would be of similar configuration and design as that for the slope below the first bench. The benches themselves would be graded toward the lower slope and would be provided a seepage collection membrane and cover layer similar to that of the adjoining slopes, except that they would also contain a stabilized road surface above the protective soil layer. The total lined area would then be about 4.5 acres.

Acid drainage from pyrite ore and fill areas beneath the lined area would be collected in a trench beneath the HDPE lining system and would be carried by a concrete-encased HDPE pipe beyond the toe of the landfill to a sump where it can be pumped to the treatment plant for treatment. Details of this acid seepage collection and removal system are shown on Sections B and D in Figures TP.01b-2 and -3.

The remaining pit sidewalls will not be lined due to their steep and irregular side-slopes. The option of constructing berms along these slopes has been deleted because of:

- The volume of the pit, which would be severely impacted by constructing even short barriers

- The low probability that dry sludge materials would contribute significant amounts of water which could enter the surficial fractures along the sideslopes

Filtrate Collection System

Conceptual filtrate collection system components are shown in Sections A and B in Figures TP.01b-1 and -2. They consist of:

- A 12-inch-minimum-thickness sand and gravel drainage layer with a system of 6-inch- to 8-inch-diameter perforated HDPE collection pipes and a 6-inch-minimum-thickness sand filter layer on the floor of the pit

- A 12-inch-minimum-thickness sand and gravel drainage layer with a 6-inch-minimum-thickness sand filter layer on the covered pyrite slopes to the first bench on the western end of the pit

The conceptual filtrate collection layer consists of natural drainage and filter materials which have been sized to conform with gypsum gradations found in the literature. Gypsum gradations were used since gypsum from sulfuric acid neutralization with lime appears to have similar properties and gradations as the sludge. On the basis of this information, preliminary filter computations suggest that Class 1, Type A, Permeable Material in Paragraph 68-1.025 of the 1992 Caltrans Standard Specifications may meet the requirements of the sand and gravel drainage layer materials. These computations also suggest that Sand Bedding Material meeting the requirements of Paragraph 19-3.025 of the same specifications may be appropriate sand filter material. Final design, however, should include gradation testing of actual HDS and Simple Mix sludge materials likely to be disposed of in the landfill and confirmation that these available materials meet standard filter criteria.

Should it be found that available natural filter and drainage materials do not meet standard filter criteria, synthetic filter materials should be reviewed for use. These materials, however, should be considered and specified carefully since there is currently some concern within the engineering community about their potential to clog and form a barrier to drainage rather than a filter.

Special Considerations

Special design and construction considerations must be included in design of the landfill to account for special site conditions. These considerations should include, but not be limited to:

- Confirmation of final slope and bench configurations to account for required static and seismic factors of safety and drainage requirements (This is extremely important if flexible membrane linings are used in the cap system since they typically require flatter slopes or special design provisions due to their low friction characteristics.)

- Modifications to normal anchoring methods for the geomembrane lining system, such as battens, rock bolts, anchors, etc., to prevent leakage at these points and as a result of difficulties in constructing conventional anchor trenches along rock slopes

- Special foundation and backfill gradation requirements, or geotextile padding layers as appropriate, to protect the geomembrane lining system from potentially abrasive or sharp materials below or above it

- Selection and protection of all construction materials to accommodate expected chemical, UV-exposure, and loading conditions at the site (This has conceptually been included with the use of HDPE lining and pipe materials and encapsulation of all concrete in an HDPE wrap. Additional work must be done for selecting and protecting other construction materials such as metals, plastics, aggregates, and geotextiles.)

- Preparation of details which will minimize the potential for clogging of the acid seep collection and removal system piping with iron precipitates (This has reportedly been done simply at Appalachian coal mine sites by having an upturned elbow at the outlet end which keeps the end of the pipe flooded, thus preventing the entrance of oxygen which is required to cause iron precipitation.)

ATTACHMENT E

BRICK FLAT PIT DISCHARGE

SYSTEM CONCEPT

PREPARED BY: Ron Stillmunkes/RDD

DATE: October 26, 1992

SUBJECT: Brick Flat Pit Discharge System
Iron Mountain Mine

PROJECT: RDD69017.TP.01c

Background

The recent Record of Decision by the EPA for significantly reducing the Acid Mine Drainage (AMD) pollution problem at Iron Mountain Mine (IMM) was to treat the AMD with a High Density Sludge (HDS) lime neutralization process. The location of the HDS treatment plant is undecided at this time, but for this analysis it is assumed to be located above Brick Flat Pit (BFP). HDS could then be discharged by gravity from the treatment plant to the pit below for disposal (see attached Figure TP.01c-1).

Currently, AMD and surface runoff discharge from BFP. The AMD is collected by an interceptor drain located on the west end of BFP and is discharged into the main storm channel. During a rainfall event, both AMD and runoff are mixed and conveyed via a storm channel to a discharge point located on the face of the large sidecast fill.

Filtrate, a third type of discharge, will be created when the pit is used for sludge disposal. The sludge and filtrate are byproducts of the HDS process. Filtrate is expected to have a fairly high pH and will be collected by some form of buried interception drain network under the sludge bed (see Technical Memorandums TP.01a and TP.01b). It is important to keep the filtrate separated from the AMD to prevent precipitates from forming and potentially clogging a conveyance system. For this analysis, separation is provided by piping the AMD and conveying the filtrate/runoff in a separate storm channel/pipeline system.

The existing AMD/runoff conveyance system at BFP is relatively new since it was installed in the fall of 1989. After only 3 years of use, a ravine is forming downstream of the discharge point on the steep sidecast fill. The need for an alternative conveyance system is further amplified by the following reasons:

- We are in a drought period and have not had many significant storms within the last 3-year period.
- Additional filtrate flow will be developed at the pit once sludge disposal begins.

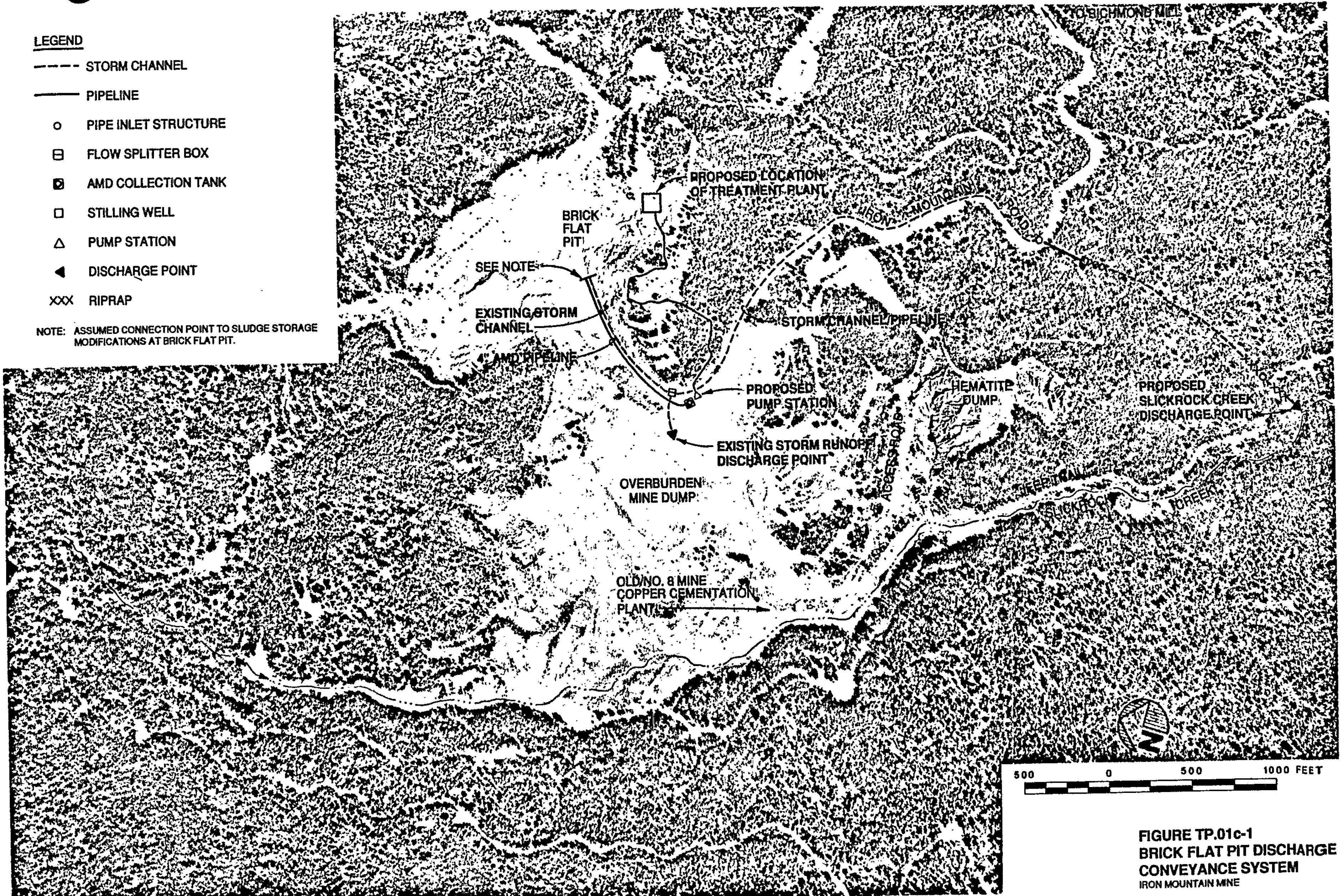


FIGURE TP.01c-1
BRICK FLAT PIT DISCHARGE CONVEYANCE SYSTEM
IRON MOUNTAIN MINE

RDD69017.TP.01 OCTOBER 1992

- The existing AMD/runoff is directed over the sidecast fill to Slickrock Creek (SRC) below. This erodes the fill, may eventually destabilize it, and contributes sediment to SRC.

- Downslope of the discharge point are the Old/No. 8 Mine seep, an existing copper cementation plant, and a potential future AMD collection system.

The new discharge system must also divert the BFP AMD, surface runoff, and future filtrate to better discharge points. This system is illustrated in Figure TP.01c-1.

The purposes of this memorandum are:

- To present the proposed discharge systems for the three BFP discharges

- To document the assumptions and design criteria used to develop the proposed BFP discharge systems

Proposed BFP Discharge Systems

AMD Discharge System

AMD will be conveyed from BFP by gravity via a buried HDPE pipeline to a buried HDPE collection tank located adjacent to a future AMD pump station site. AMD will be pumped from the buried tank into an aboveground HDPE collection tank where it may be mixed with Richmond, Lawson, and Old/No. 8 Mine AMD. A main AMD pump station could pump the AMD mixture from the above-ground tank to the HDS treatment plant.

Filtrate/Runoff Discharge System

The existing AMD/runoff discharge system at BFP consists of a combination of open channel ditches, pipelines, and various structures. Just upstream of the main storm channel outlet, the main ditch flow is conveyed under the pit entrance road through a pipe inlet structure and three buried 24-inch-diameter PVC pipelines each about 150 feet long.

The existing surface runoff channel at the pipe inlet structure was designed for a 100-year design storm event which results in a maximum design flow of 75 cfs based on 1989 design notes. The maximum estimated filtrate flow is 215 gpm or about 0.5 cfs. Therefore, surface runoff will determine the size of this new filtrate/runoff discharge system (FRDS). However, a 100-year design storm may be excessive, especially when comparing it to a 30-year project life.

In order to maintain the 100-year outlet flow condition and still significantly reduce the amount of storm flow eroding the sidecast fill, the following design criteria are used:

- The new FRDS will divert a 25-year design storm (62 cfs) to a natural storm channel located downslope along the main access road. The natural storm channel selected will not traverse any mine dumps and will outlet to SRC.

- The remaining 13 cfs during a 100-year storm will be diverted with a new flow-splitting structure, over a weir into the existing pipe inlet structure, and will follow the existing flow path over the sidecast fill to SRC.

An FRDS system was developed using the criteria above and the assumptions below. Filtrate and surface runoff (FR) will flow into the existing storm channel located just outside of the BFP sludge storage area. From there the FR will flow to a new concrete-reinforced flow splitter box. During a 100-year storm event, this box will divert about 13 cfs to the existing storm outlet system and 62 cfs downslope through the FRDS. The new FRDS route will follow the mountain side of the main access road and cross under the road approximately 3,000 feet from the box. This portion of the route is assumed to be a combination of open ditches and pipelines. A pipeline will be required to convey the FR under the road and down slope to the crossing of the Old/No. 8 Mine access road. On the downstream side of this crossing, a pipe drop energy dissipation (stilling well) structure and riprap are required. FR will flow from this structure into a riprapped channel section, to a natural channel, and eventually to the jeep trail just above SRC. Modifications at this location include riprap both upstream and downstream of the crossing, a pipe inlet structure, and a buried pipeline that will convey FR to the riprapped slope just above SRC.

Note that filtrate could also be recycled at the flow-splitter box if necessary.

Design Assumptions and Criteria

General facility sizing criteria used are given below. Related costs are reported elsewhere.

- Design Flows

  - AMD Discharge
    Peak = 15 gpm
    Average Annual = 5 gpm

- Filtrate/Runoff Discharge
  Peak to Splitter Box = 75 cfs
  Peak Downstream of Splitter Box = 62 cfs
  Peak to Existing System Discharge = 13 cfs

- Maximum pipeline friction loss = 8 ft. of friction head per 1,000 ft. of pipe

- The Manning's roughness coefficient will include losses for both pipe friction and miscellaneous fittings. This coefficient will be equal to 0.011.

- Pipeline material must withstand the extremely corrosive and potentially erosive characteristics of the AMD. High Density Polyethylene (HDPE) pipeline material is currently being used and will be assumed based on information from the Driscopipe catalog.

- A very durable pump is required for the same pipeline material reasons given above. Therefore, assume that the pump will be slurry type with a pump efficiency of 40 percent.

- Redundancy will be accomplished by an additional pump and a standby generator at the pump station.

ATTACHMENT F

AMD QUALITY AND QUANTITY ESTIMATES

TECHNICAL MEMORANDUM No. TP.02

PREPARED BY: Peter Lawson/Redding

DATE: September 23, 1992

SUBJECT: Quality and Quantity Estimates for Portal AMD Flows
Iron Mountain Mine

PROJECT: RDD69017.TP.02

This memorandum presents the results of calculations performed to estimate the quality and quantity of flows from the Richmond and Lawson portals and the Old/No. 8 Mine seep at the Iron Mountain Mine Superfund Site. The quantities estimated include the average annual portal flows, the peak flows for various return period storms, the average wet weather flows, and the dry weather base flows. The water-quality evaluation focused on the variation of copper, cadmium, and zinc concentrations and pH with respect to flow rate. These estimates will be used to estimate the required treatment capacity for a lime neutralization facility designed to support two alternatives: (1) treatment of the Richmond portal and Lawson portal discharges and (2) treatment of the Richmond portal, Lawson portal, and Old/No. 8 Mine seep discharges.

Conclusions

The main conclusions developed during the course of this investigation are presented below.

Richmond Portal Flows

- Annual Average Flow = 56 gpm
- Winter Average Flow = 125 gpm
- Summer Base Flow = 10 gpm
- Peak Observed Flow = 800 gpm (estimated)

Lawson Portal Flows

- Annual Average Flow = 40 gpm
- Winter Average Flow = 95 gpm
- Summer Base Flow = 15 gpm
- Peak Observed Flow = 236 gpm

Old/No. 8 Mine Seep Flows

- Annual Average Flow = 59 gpm
- Winter Average Flow = 140 gpm
- Summer Base Flow = 15 gpm
- Peak Observed Flow = 231 gpm

pH Measurements

- Richmond Portal: 0.5 to 1.0
- Lawson Portal: 1.25 to 1.75
- Old/No. 8 Mine Seep: 2.25 to 2.75

Copper Concentrations

- Richmond Portal: 100 to 600 mg/l
- Lawson Portal: 50 to 150 mg/l
- Old/No. 8 Mine Seep: 100 to 175 mg/l

Cadmium Concentrations

- Richmond Portal: 7 to 20 mg/l
- Lawson Portal: 2 to 6 mg/l
- Old/No. 8 Mine Seep: 0.4 to 0.7 mg/l

Zinc Concentrations

- Richmond Portal: 1,000 to 2,500 mg/l
- Lawson Portal: 300 to 800 mg/l
- Old/No. 8 Mine Seep: 40 to 70 mg/l

Portal Flow Estimates

Average flows were calculated using a numerical integration technique. Each observed data point was assumed to represent flow conditions from halfway between the observed value and the previous observation to halfway between the observed value and the subsequent observation. This technique may have introduced errors when large periods of time passed between flow measurements. The base flow estimate represents low flow conditions during the summer months when portal flows are assumed to be sustained by groundwater base flow. The winter average flow reflects the average flow during wet weather periods when the portal flows are elevated above the annual average value and persist for a minimum of 30 days. Finally, the peak observed flow is the maximum flow event that was observed at the portal over the period of record.

Richmond Portal

The average portal flows calculated for the Richmond portal and the available length of record is presented in Table TP.02-1. These averages are based on a period of record from 1983 to 1992. The data indicate an average flow of about 60 gpm, a winter average of 125 gpm, a summer base flow of 10 gpm, and a maximum recorded peak of 800 gpm on February 18, 1986.

Table TP.02-1
Flow Data For Mine Portals
Iron Mountain Mine

	Richmond	Lawson	Old/No. 8 Mine
Data Record	1983 to 1992	1983 to 1992	1978 to 1992
No. of Measurements	444	319	308
Annual Average	56 gpm	40 gpm	59 gpm
Base Flow	10 gpm	15 gpm	15 gpm
Winter Average	125 gpm	95 gpm	140 gpm
Peak Observed	800 gpm[a]	236 gpm	231 gpm[b]

[a]This flow value is estimated and may contain significant error.
[b]A 679-gpm flow estimate on December 1, 1983, was omitted from this data set since no precipitation event occurred during this period to produce this high flow.

The average flow values presented above are based solely on observed flow events that occurred at the site during the period of record. These estimates do not address future flow conditions that may occur at the site during more extreme rainfall events. To address this issue, a probabilistic analysis was employed. The first step in the analysis was to estimate the infiltration rate for precipitation falling on the Spring Creek watershed during storm events. To estimate this quantity, the area of the Spring Creek watershed was estimated, and the daily rainfall at the site was converted into a rainfall rate. This rainfall rate was then compared to the calculated inflows into Spring Creek Reservoir obtained from United States Bureau of Reclamation (USBR), and the difference between the rainfall and runoff was assumed to infiltrate. This process was repeated for all significant storms where elevated portal flow data were available. To account for the lag time between rainfall and portal flow response, 4-day storm events were also evaluated in a similar manner. The results of this analysis suggest that approximately 60 percent of the precipitation that falls over the watershed during wet weather conditions will infiltrate, and the remaining 40 percent will travel downstream and enter Spring Creek Reservoir.

Once a site-specific infiltration rate was estimated, the precipitation depth-duration-frequency graph for the Shasta Dam weather station (Figure TP.02-1) could be used to quantify potentially larger rainfall events that might occur at the site. By using the

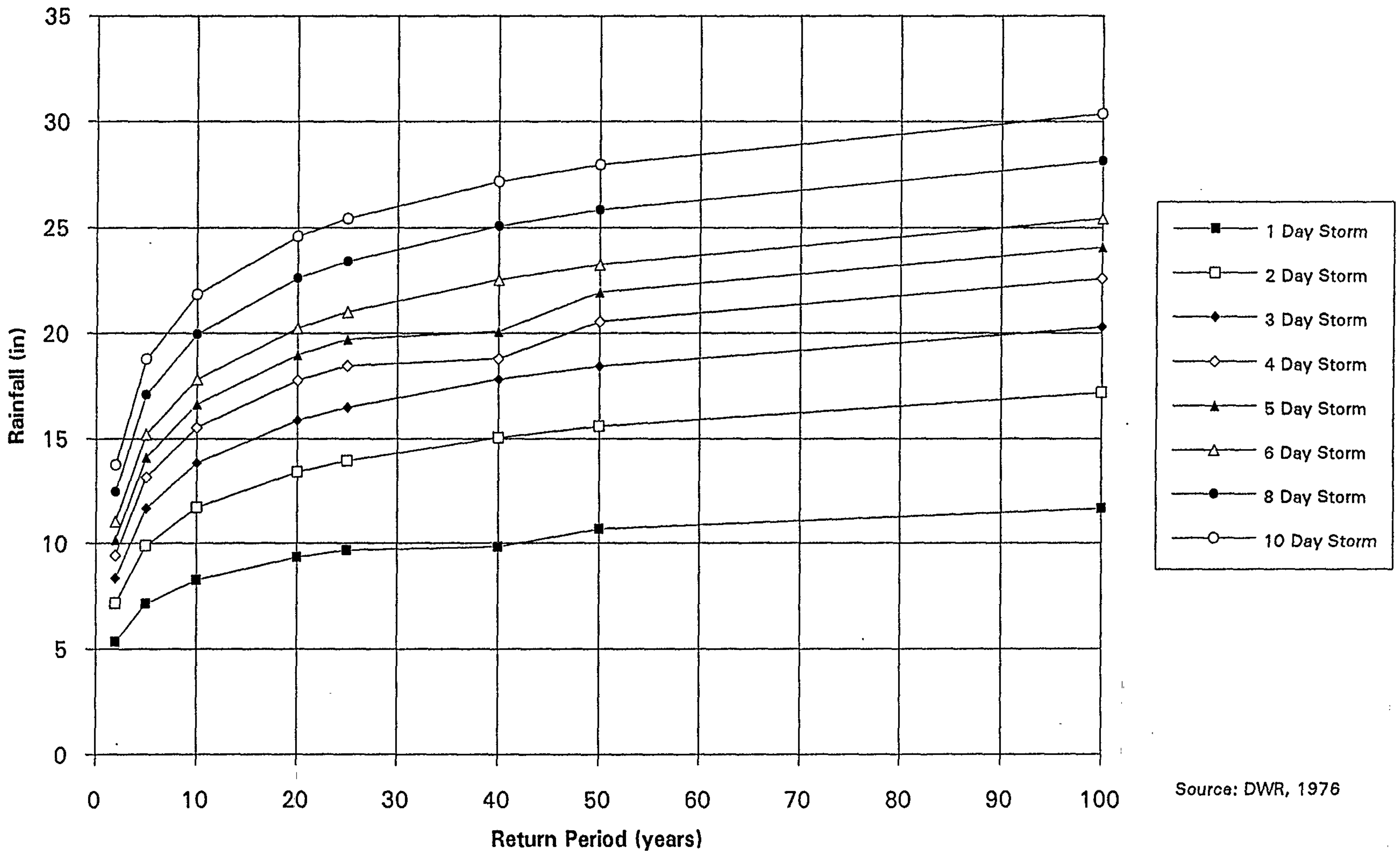


FIGURE TP.02-1
PRECIPITATION DEPTH-DURATION-FREQUENCY CURVES FOR SHASTA DAM
IRON MOUNTAIN MINE

area of the Richmond Mine Workings and a 60 percent infiltration rate, these storm events could be converted to potential portal flow events that would result. The results of this analysis are presented as Figure TP.02-2. It should be noted that the portal flows estimated using this technique are maximum values for the indicated rainfall events. This analysis assumes that all rain that infiltrates above the Richmond Mine will immediately travel to the portal. Any obstructions or constrictions that exist in the mine (mine pools, acid mine drainage (AMD) impoundments, plugged ore chutes leading from stoped areas) will act to equalize the portal flow response to rainfall events and reduce the peak flows observed from the portals. Since plugged ore chutes and AMD impoundments have been observed in the Richmond Mine, flows as high as 2,400 gpm (Figure TP.02-2) may not be likely to occur, even in extreme events. However, flows substantially higher than the observed maximum flow to date (800 gpm) appear likely if storms with return periods greater than 10 years occur in the future. One other complicating factor in these predictions are the partial caps constructed in 1989. These partial caps will also likely reduce the magnitude of peak flows from the mine.

To investigate the potential response of the Richmond Mine to shorter duration storm events, an alternative means was necessary to estimate the infiltration rate at the site. The method described above uses daily to weekly data and is not relevant to the response of the watershed to shorter duration, higher intensity storm events. As an alternative, the Soil Conservation Service (SCS) runoff curve method (USDA, 1972) was used to estimate infiltration rates. This method indicated that for 12-hour storms of return periods from 2 to 25 years, the infiltration rate will vary from 45 to 60 percent. Figure TP.02-2 also presents the predicted portal flows for a 12-hour storm of varying return periods. These results suggest that the maximum flow produced by a 12-hour storm will not be significantly higher than those predicted for a 1-day event. In general, the duration of the peak flow event for a given storm is directly dependent on the duration of that particular storm event.

Lawson Portal

The average portal flows calculated for the Lawson portal are listed in Table TP.02-1. Calculations suggest that the portal will have an annual average flow of about 40 gpm, a winter average flow of 95 gpm, and a base flow of 15 gpm. The highest recorded flow from the Lawson portal is 236 gpm on February 18, 1986.

The peak flow predictions for high intensity storm events were estimated using the same technique described in the Richmond portal analysis. The flow from the Lawson portal was assumed to originate entirely from the Hornet Mine; therefore, this area of the Hornet Mine was used to calculate inflows to the Lawson Tunnel. Personal communication with a previous employee of Stauffer Chemical indicates that, as of the early 1970s, the declines that could potentially connect the Richmond Mine to the Lawson Extension were completely plugged with muck, and AMD pools tens of feet deep resided in the declines. Attempts were reportedly made to blast the muck plugs with explosives, but no connection could be achieved. Previous geochemical studies have been performed to compare the chemistry of the Richmond

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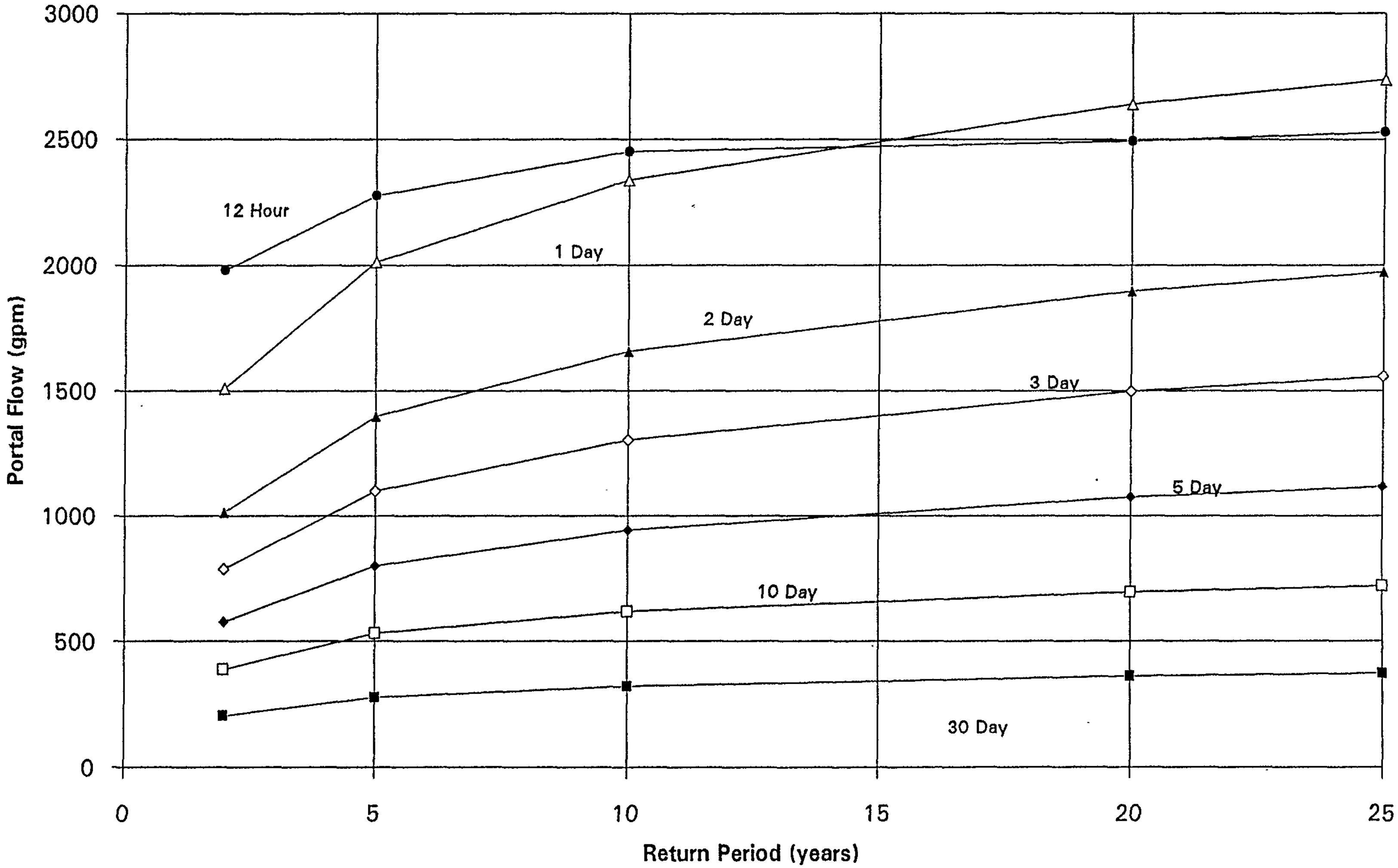

FIGURE TP.02-2
ESTIMATED RICHMOND PORTAL STORM FLOWS (OF INDICATED DURATION)
IRON MOUNTAIN MINE

and Lawson portal flows. These studies conclude that the Lawson portal drainage originates from a different source than the Richmond portal flow (Alpers et al., 1992). Figure TP.02-3 presents the estimated flows that may occur at the Lawson portal in response to large storm events. Flows approaching 500 gpm are predicted for storms with a 25-year return period.

Portal flow estimates were also calculated for 12-hour storm events of varying return periods. These results are shown in Figure TP.02-3. As in the case of the Richmond portal, the 12-hour peak flow predictions are similar in magnitude to the 1-day events.

Old/No. 8 Mine Seep

The average flow values calculated for the Old/No. 8 Mine seep are presented in Table TP.02-1. The data indicate an average flow of about 60 gpm, a winter average of 140 gpm, a summer base flow of 15 gpm, and a maximum observed peak of 231 gpm on December 16, 1983. A peak flow value of 679 gpm on December 1, 1983, was not included in these average values. This data point was considered to be in error because no large precipitation events preceded this flow event, and elevated portal flows were not observed from the Richmond and Lawson portals during this period.

Peak flow calculations similar to those performed for the Richmond and Lawson portals were attempted, using data from the Old/No. 8 Mine seep. Evaluation of the flow data suggested that the Old/No. 8 Mine system behaves fundamentally different than the other mines, and the assumptions used in the Richmond and Lawson analyses do not hold true for the Old/No. 8 Mine. More specifically, the assumption that the precipitation that infiltrates into the mine immediately travels to the portal is not valid for the Old/No. 8 Mine system. Flow records from the Old/No. 8 Mine seep indicate that elevated portal flows lag rainfall by several days, and the magnitude of the peak flows from the Old/No. 8 Mine seep are much smaller than those observed at the Richmond portal. This indicates that obstructions or constrictions in the flow system prevent the infiltrating rainfall from quickly traveling to the portal.

A comparison between the Richmond portal flows and the Old/No. 8 Mine flows illustrates the difference in behavior of the two systems. The average flow from both sources is similar; therefore, the total volume of water that moves through both mines each year is similar. But the peak flows observed from the Richmond portal are regularly four to five times the flows observed from the Old/No. 8 Mine seep. The actual mechanism by which the peak flows are reduced at Old/No. 8 Mine is unknown. One possible explanation is that a portion of the Old/No. 8 Mine workings is flooded by groundwater. Figure TP.02-4 illustrates the relative positions of the Old/No. 8 Mine workings and Slickrock Creek. Portions of the Old/No. 8 workings lie as much as 200 feet below the current invert of Slickrock Creek, suggesting they are likely flooded by groundwater. The existence of a section of flooded mine workings could produce damped portal flow responses, but no field evidence has been collected to support this hypothesis.

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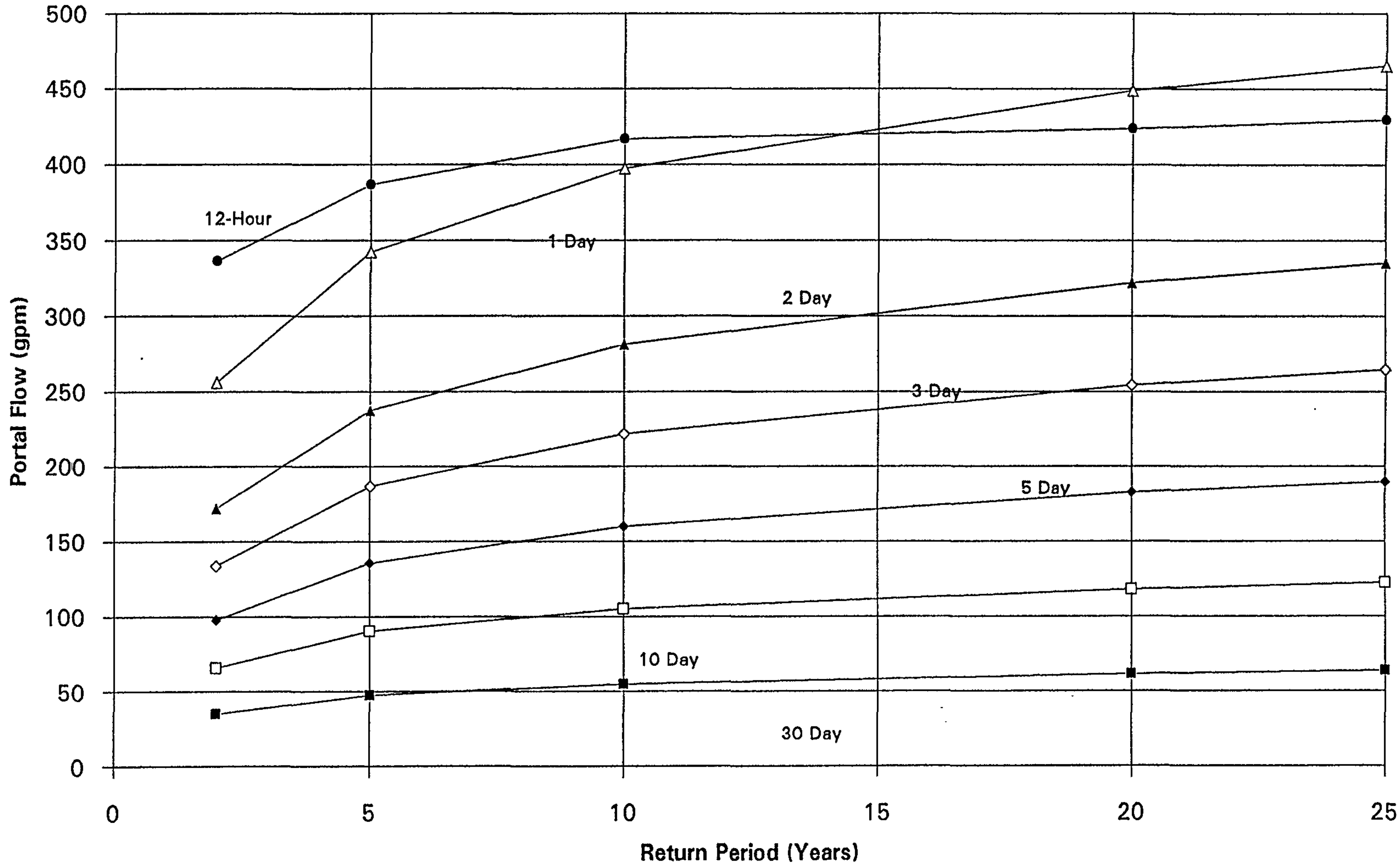
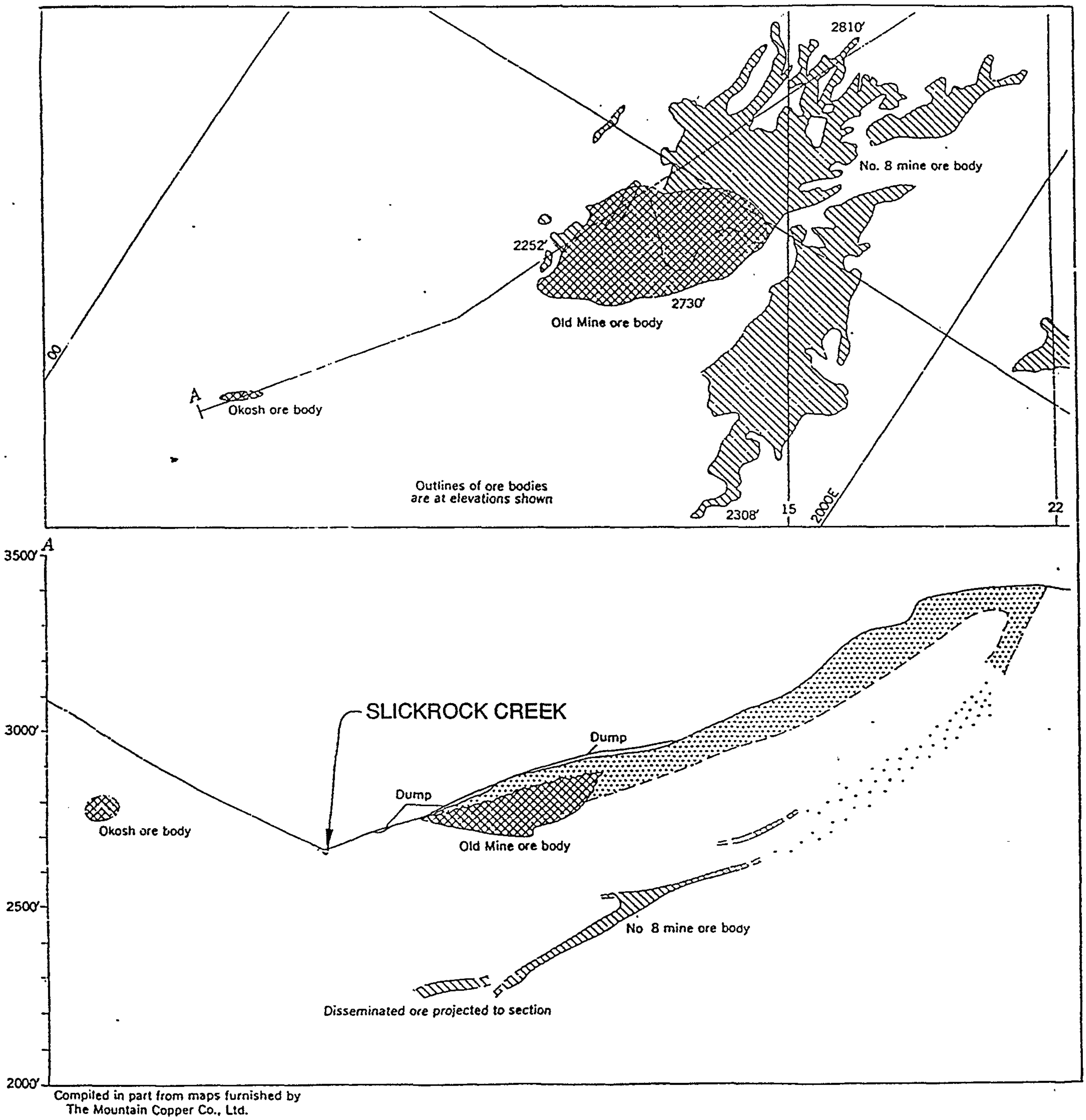


FIGURE TP.02-3
ESTIMATED LAWSON PORTAL STORM FLOWS (OF INDICATED DURATION)
IRON MOUNTAIN MINE



SOURCE: KINKEL AND ALBERS, 1956

FIGURE TP.02-4
ORE BODIES WITH RESPECT TO SLICKROCK CREEK
IRON MOUNTAIN MINE

As a result of the uncertainty described above, no peak flows from the Old/No. 8 Mine seep could be predicted in response to large future storm events. It may be reasonable to assume that Richmond portal flows will continue to be four times the Old/No. 8 Mine seep flows during extreme rainfall events. If this is true, flows from the Old/No. 8 Seep will probably not exceed 400 to 500 gpm.

Water Quality

pH Measurements

Measurements of pH in portal flows at the site were compared to determine if significant differences exist between sources, and to investigate any correlation between pH and portal flow rate. Figure TP.02-5 presents the pH data collected from the Richmond and Lawson portals and the Old/No. 8 Mine seep for the period of record indicated in Table TP.02-1. The three sources have very different pH values over the entire range of observed flows. The pH of the Richmond portal flow is between 0.5 and 1.0 for most observations. No obvious correlation exists between Richmond portal flow rate and pH. The pH of the Lawson portal flow is predominantly between 1.25 and 1.75. No clear correlation exists between pH and flow rate. The pH of the Old/No. 8 Mine seep is predominantly between 2.25 and 2.75 although these data show more scatter than data from the other two sources. No clear correlation was found between the pH of the Old/No. 8 Mine seep and flow rate.

Copper

The measured copper concentrations from the three sources over the period of record are presented in Figure TP.02-6. The Richmond portal flows have the highest copper concentrations (up to 550 mg/l) and extremely variable measurements between 100 and 600 mg/l. No clear correlation between copper concentration and flow rate could be developed. The copper concentration of the Lawson portal flow is more consistent, with most measured values between 50 and 150 mg/l. No clear correlation between Lawson portal flow rate and copper concentration is evident. The copper data collected from the Old/No. 8 Mine seep are the most consistent, with most measurements falling between 100 and 175 mg/l. These data suggest that copper concentration is independent of flow rate. This is consistent with the hypothesis that a portion of the Old/No. 8 Mine Workings is flooded. If a mine pool exists in the workings, variation in water quality could be equalized by mixing of infiltration water into the mine pool prior to discharge.

Cadmium

The correlation between cadmium concentration and flow rate for the three sources is presented in Figure TP.02-7. The data show a distinct separation between data from different sources. The highest cadmium concentrations were observed in Richmond portal discharges with values as high as 24 mg/l. There is a weak trend of decreasing

Comparison of pH Measurements

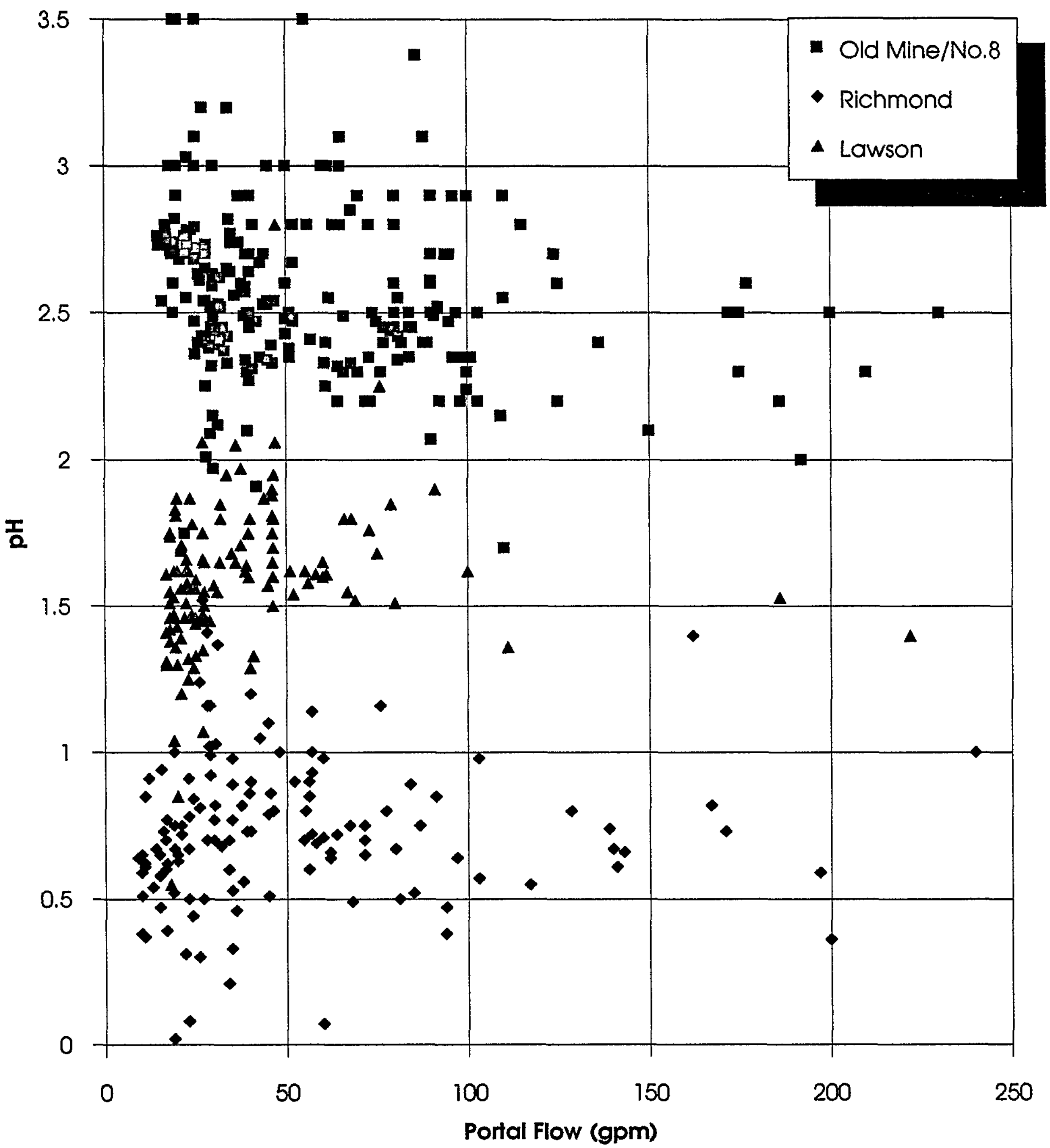


FIGURE TP.02-5
COMPARISON OF
pH MEASUREMENTS
IRON MOUNTAIN MINE

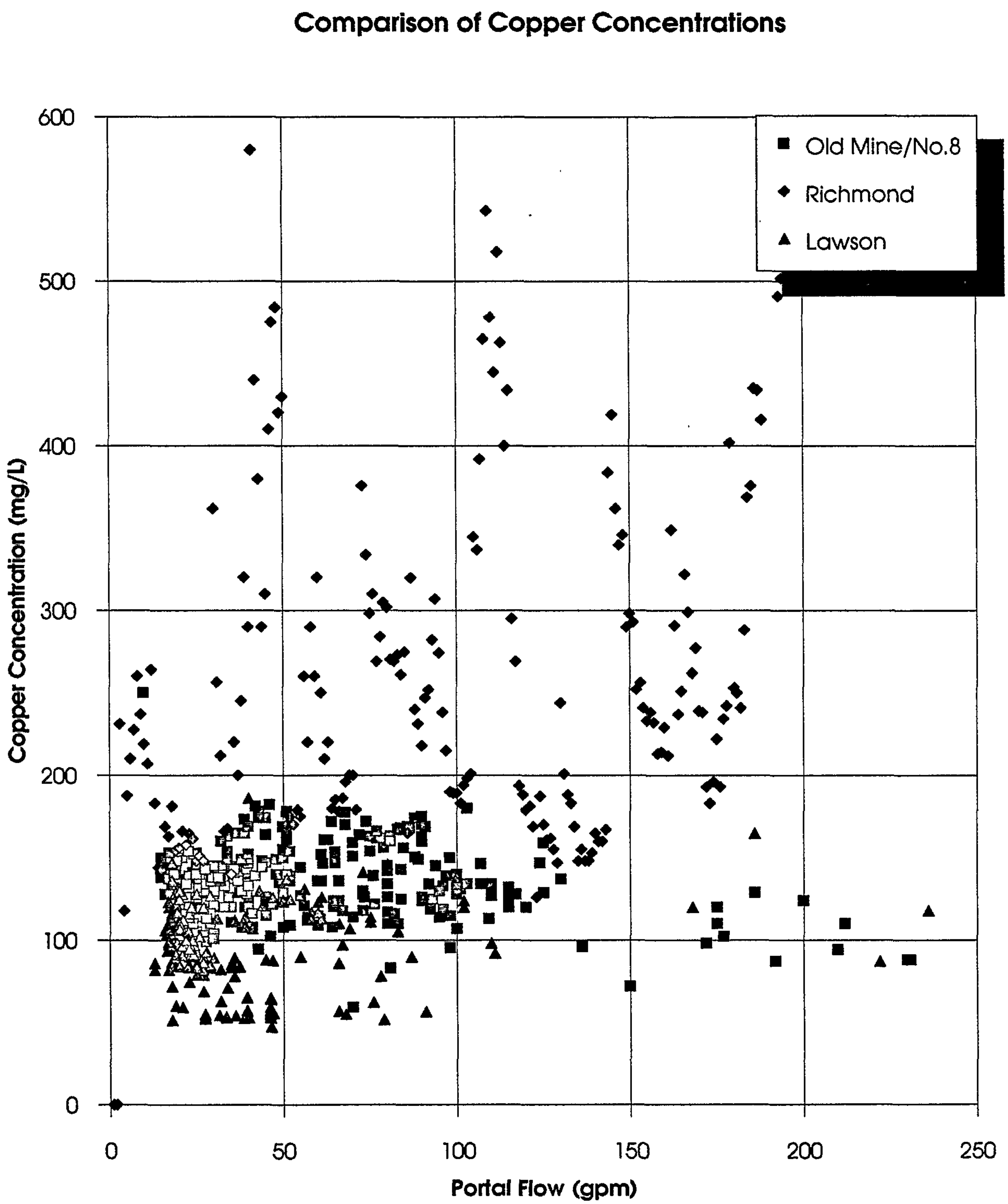


FIGURE TP.02-6
COMPARISON OF
COPPER CONCENTRATIONS
IRON MOUNTAIN MINE

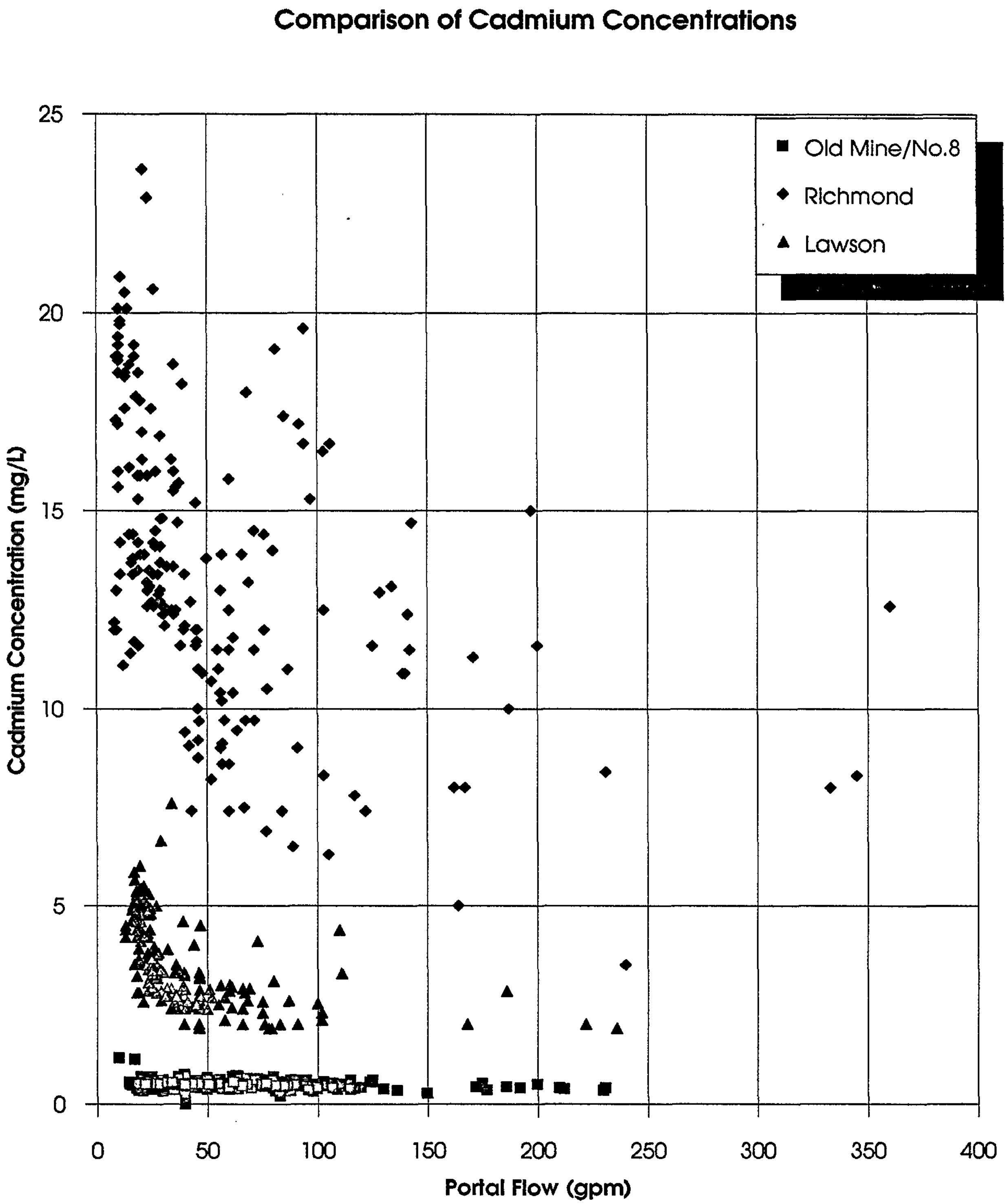


FIGURE TP.02-7
COMPARISON OF
CADMIUM CONCENTRATIONS
IRON MOUNTAIN MINE

suggests that the rate of cadmium input to the system is limited, and cadmium concentrations become diluted at high flow rates. The cadmium data from the Lawson portal show a strong inverse relationship between cadmium concentration and flow rate. These data trace a typical dilution curve and suggest a limited rate of cadmium contribution to infiltrating waters in the Hornet Mine. The cadmium concentration measurements from the Old/No. 8 Mine seep suggest that cadmium concentration is independent of flow rate. There is almost no difference in cadmium concentrations (0.4 to 0.7 mg/l) measured between flow rates of 25 and 250 gpm. As discussed above, this distribution of data is consistent with a mine pool acting to equalize water quality in the Old/No. 8 Mine Workings.

Zinc

The distribution of the zinc concentrations versus flow rate are very similar to the distribution of cadmium concentrations (Figure TP.02-8). This parallel behavior between cadmium and zinc has been observed in previous geochemical studies, and it has been suggested that the distribution of these two metals is so similar that you could calculate the concentration of one element in a sample by knowing the concentration of the other (Alpers et al., 1992). The zinc measurements taken at the Richmond portal show the highest concentrations, exceeding 2,500 mg/l. A faint inverse relationship between zinc concentration and flow rate can be discerned from the data. The zinc measurements from Lawson portal discharges show a strong correlation between decreasing zinc concentration and increasing flow rate. As discussed above, this behavior may indicate a limited rate of zinc contribution to mine waters. The zinc concentrations measured in the Old/No. 8 Mine seep are essentially independent of flow rate.

ATTACHMENT G

TREATMENT PLANT DESIGN CRITERIA

PREPARED BY: Dana Rippon/Redding
Linda Mohr/Redding

DATE: October 26, 1992

SUBJECT: Treatment Plant Design Criteria
Boulder Creek Operable Unit
Iron Mountain Mine

PROJECT: RDD690178.TP.03

Introduction

The purpose of this technical memorandum is to define the performance requirements of a long-term acid mine drainage (AMD) neutralization facility located at the Iron Mountain Mine project site. A conceptual treatment plant design was prepared to develop minimum design requirements and criteria for compliance with the September 30, 1992, Record of Decision (ROD) for the Boulder Creek Operable Unit (OU). The conceptual design is described below. The detailed design, construction, and operation of the facilities required to meet the prescribed treatment objectives are not addressed and shall be the responsibility of the Responsible Parties.

While there are several point and non-point sources of AMD from the project site, the flows to be treated are from the Lawson portal and the Richmond portal. Further, there is potential for inclusion of flows from the Old/No. 8 Mine seep at a later date. As evidenced in the findings of the Feasibility Study for the Boulder Creek OU and Technical Memorandum TP.02, treatment of AMD from these sources will significantly reduce the total contamination from the project site.

Design criteria for two conceptual AMD conveyance and treatment scenarios are presented. Under Option 1, AMD flows from the Richmond and Lawson portals are considered; under Option 2, Richmond Portal, Lawson Portal, and Old/No.8 Mine seep flows are included. The design assumes collection of AMD at the portals, conveyance of AMD to the treatment plant, equalization at the treatment plant site, lime/sulfide High Density Sludge (HDS) neutralization, and residuals disposal in Brick Flat Pit.

Two locations for the treatment plant at the project site are under consideration. The first is at the top of Iron Mountain near Brick Flat Pit; the second is at Minnesota Flats. The locations of these potential sites are shown in Technical Memorandum TP.05. Design criteria for the treatment plant at each location will vary somewhat in accordance with the needs of the particular site to provide comparable process reliability and sludge handling options.

General Design Criteria

The conceptual treatment plant design is based on the following general assumptions:

- All pumping and treatment facilities shall be designed and constructed for a minimum 30-year service life. All equipment shall be selected for a minimum 15-year service life. All materials of construction shall be in compliance with the recommendations of Technical Memorandum TP.04.

- Firm capacity shall be provided by all equipment and process tankage vital to the treatment of AMD. **Firm capacity** shall be defined as the treatment capacity or the chemical feed or product handling capacity that is provided with the single largest installed unit out of service. Further, firm capacity shall be based on normally encountered reasonable operating criteria and shall not depend on stressing process units beyond their normal operating range.

- The conveyance and treatment facilities shall be designed to accommodate potential future expansion.

- The treatment process shall be lime/sulfide high density sludge (HDS) neutralization.

- The treatment process shall meet the effluent limitations of the Clean Water Act-Effluent Guidelines and Standards for Ore Mining and Dressing of 40 CFR §440.102(a) and §440.103(a) except as provided for in the ROD.

- A landfill shall be constructed in Brick Flat Pit for the disposal of all process residuals.

AMD Collection and Conveyance

AMD will be collected at the Richmond portal and the Lawson portal; AMD from Old/No. 8 Mine seep may also be treated. Table TP.03-1 summarizes the design flow data for these point sources. Detailed flow data can be found in Appendix A. While these values appear appropriate for design purposes, it must be recognized that limited data exist regarding observed portal flow rates. These design values will be subject to adjustment based on actual operating experience. As of the date of preparation of this memorandum, data analysis is scheduled for further scrutiny. Revised AMD flow numbers for purposes of facility design will be developed and presented prior to commencing the preliminary design.

Table TP.03-1 AMD Portal Flow, gpm				
Flow	Richmond	Lawson	Old/No.8	Total
Low[a]	10	15	15	40
Average[b]	60	40	60	160
Peak[c]	800	250	250	1,300
Winter[d]	130	100	140	370
[a]Low = Typical Summer Low Flow [b]Average = Average Annual Flow [c]Peak = Maximum Observed Flow [d]Winter = Average Sustained High Flow				

AMD Pump Stations (If Required)

AMD will be conveyed to the treatment plant either by gravity or pumped transmission lines. If the facility is located at Minnesota Flats downgradient of the portals, gravity conveyance is feasible. If the plant is located at the top of Iron Mountain near Brick Flat Pit, the following criteria will apply to the conveyance system. In the case of treating AMD from Old/No. 8 Mine Seep, additional pumping will be required either up to Brick Flat Pit or over to the nearest point of juncture in the gravity system to Minnesota Flats.

The AMD pump stations shall be sized for the peak anticipated flow rates: a minimum of 1,050 gpm for Option 1 (Richmond and Lawson flows) and a minimum of 1,300 gpm for Option 2 (Richmond, Lawson, and Old/No.8 flows).

The Record of Decision requires the interception, conveyance, and treatment of all AMD flows emanating from the said portals. Engineering analysis and peak flow rates observed to date indicate that the listed minimum flow rates appear appropriate. However, should actual operational experience indicate that higher instantaneous flow rates can occur, the system shall be modified to provide all required firm capacity to intercept and treat AMD flow rates at least as great as the new information indicates.

The AMD pumps shall be slurry type pumps. The pumps will be installed in series, if required, to meet the high head conditions created in moving the AMD to the top of the mountain. The maximum total dynamic head per lift shall be limited to 300 feet for reliable performance from high density polyethylene (HDPE) pipe, particularly during the summer, when AMD fluid temperatures may be high. Figure TP.03-1 shows the assumed series of pump stations needed to move AMD to a treatment plant at Brick Flat Pit for Options 1 and 2.

Each pump station facility will include an HDPE AMD storage tank. The tank shall be sized for the maximum volume required by the following criteria:

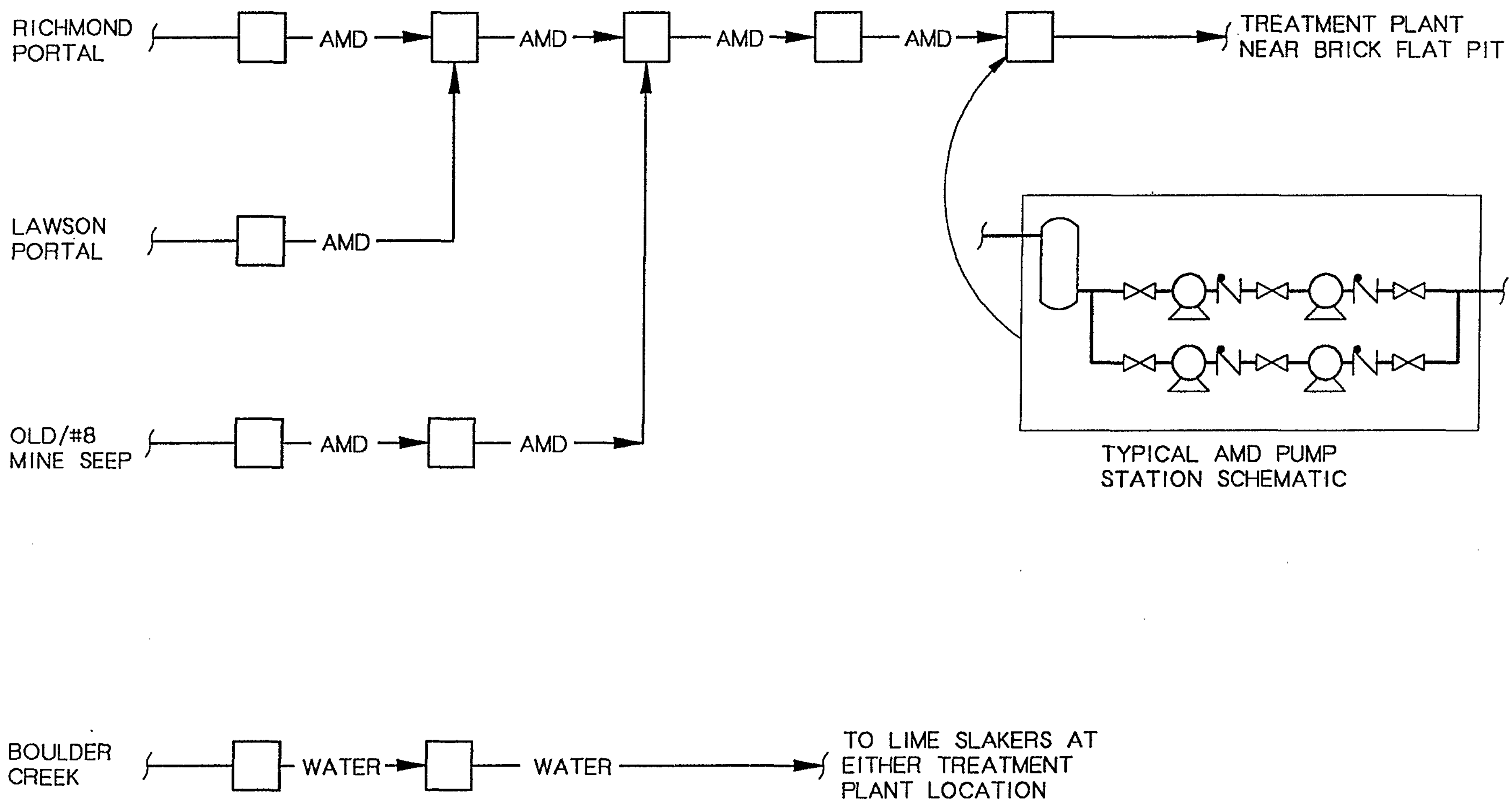


FIGURE TP.03-1
AMD AND WATER CONVEYANCE SYSTEM SCHEMATICS
WET LANDFILL CONCEPT
IRON MOUNTAIN MINE

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1. Sufficient volume to permit a minimum cycle time of 10 minutes for the AMD pumps

2. Sufficient volume to contain the entire contents of the pump station discharge line to permit emptying the pipeline for maintenance

3. Sufficient volume to equalize flow peaks greater than the maximum observed flow, as reviewed and approved by EPA

AMD pumps shall be controlled on levels measured in the pump station storage tank.

An access road shall be provided to each AMD pump station. Each pump station shall also include provisions for both routine and emergency electrical power. The emergency power source shall be sized for the maximum pumping horsepower output and have sufficient fuel storage for 48 hours' continuous operation.

AMD Transmission Pipelines

Because the treatment may be located near Brick Flat Pit or at Minnesota Flats, AMD transmission pipelines may be designed for gravity or pressurized service. Regardless of the service condition, all AMD transmission pipelines shall adhere to the following criteria:

- Pipe shall be very high molecular weight HDPE as specified by ASTM D 3350 with a cell classification of PE 355434C. The minimum pressure class rating shall be 160 psi (SDR 11).

- Pipeline construction shall be above ground except where road crossings are required. Pipelines shall be routed wherever possible adjacent to Iron Mountain Mine Road or other roads for direct access.

- Provisions shall be made to protect the pipeline from damage resulting from freezing, landslides, land subsidence, and vehicular traffic.

- Pressurized lines shall be sized for a maximum allowable friction loss rate of 8 feet/1,000 feet given a Hazen-Williams coefficient of 140.

- The pressured pipeline between the Lawson and Richmond portals shall have a pressure class rating of 265 psi at a fluid temperature of 73.4°F.

- Gravity pipelines shall be designed for the following hydraulic conditions:

  - Open channel flow

- Size pipe to pass peak design flow at a fluid depth to internal diameter ratio of 0.75
- A Manning's "n" coefficient of 0.012

Treatment Plant Overview

In the ROD, both the type of neutralization process and the treatment capacity were selected for the treatment plant. The HDS process shall be used to treat sustained elevated flows from the Richmond and Lawson portals. These flows are represented as the "winter" flows shown in Table TP.03-1: 230 gpm for Option 1 and 370 gpm for Option 2. The treatment plant must also be capable of handling the peak observed AMD flows: at least 1,050 gpm for Option 1 and at least 1,300 gpm for Option 2. Provision shall be incorporated in the facility layout to accommodate expansion of treatment capacity, should experience warrant a greater treatment capability.

In developing design criteria for the individual components of the treatment plant, some assumptions were made to establish a minimum level of redundancy and system reliability. These assumptions are also based on treatment plant location. As previously noted, design criteria for the treatment plant are site-specific to Brick Flat Pit and Minnesota Flats. The assumed overall treatment capacity of the two plants is as follows:

- **Brick Flat Pit**—For Option 1, 300 gpm HDS treatment capacity and 1,050 gpm Simple Mix treatment capacity. For Option 2, 300 gpm HDS treatment capacity and 1,300 gpm Simple Mix treatment capacity. Refer to Figure TP.03-2 for assumed treatment plant process schematic.

- **Minnesota Flats**—For Options 1 and 2, 600 gpm HDS treatment capacity. Refer to Figure TP.03-3 for the assumed treatment plant process schematic.

Following the discussions below of equalization, lime feed systems, neutralization, sludge disposal, and plant services is an overall summary table of design criteria for major treatment plant components.

AMD Equalization

For purposes of the treatment plant design, equalization of AMD either in-mine or integral to the conveyance facility will not be considered. All AMD equalization will be assumed to be required at the treatment plant site.

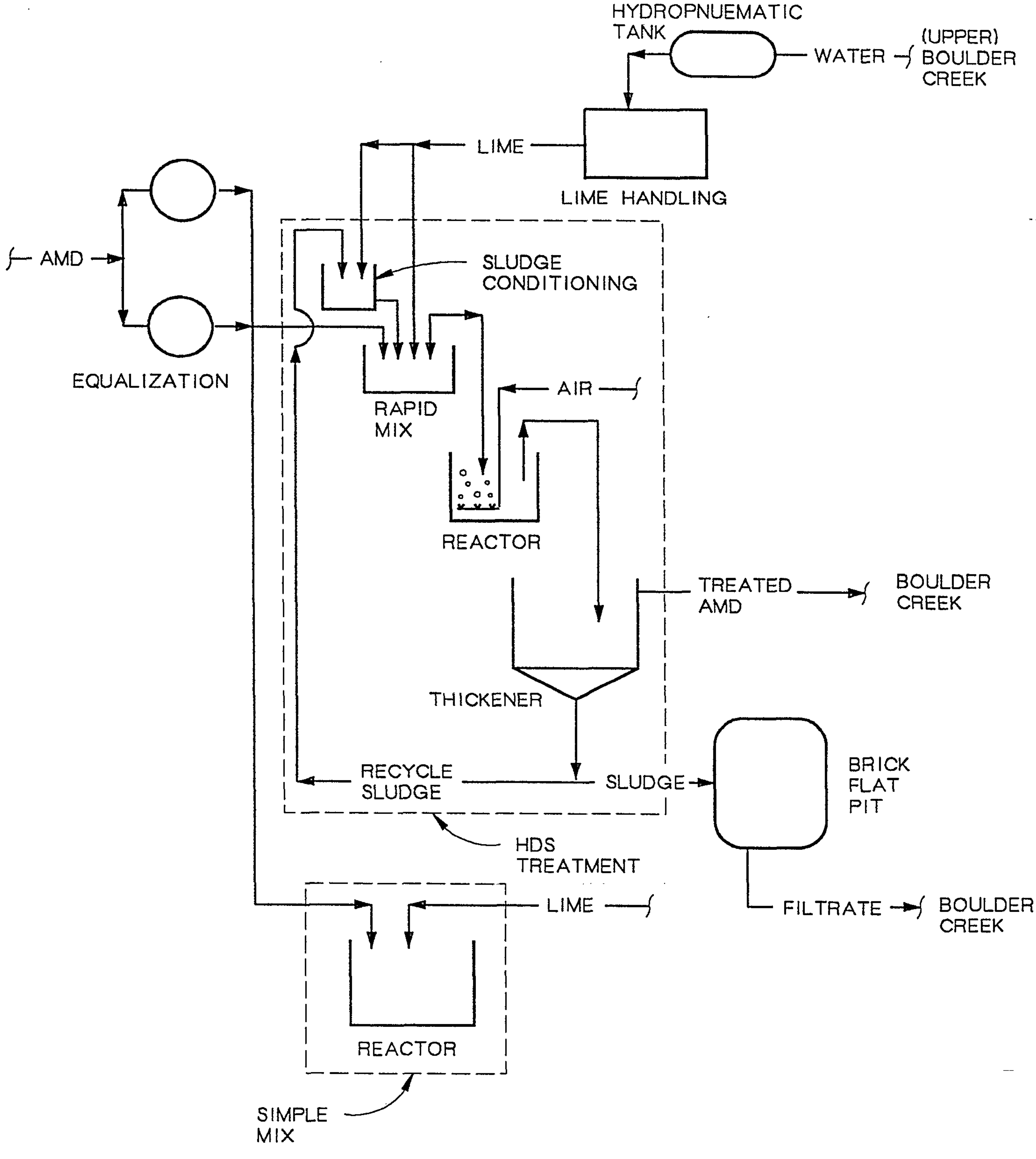

FIGURE TP.03-2
TREATMENT PLANT PROCESS SCHEMATIC
NEAR BRICK FLAT PIT
WET LANDFILL CONCEPT
IRON MOUNTAIN MINE

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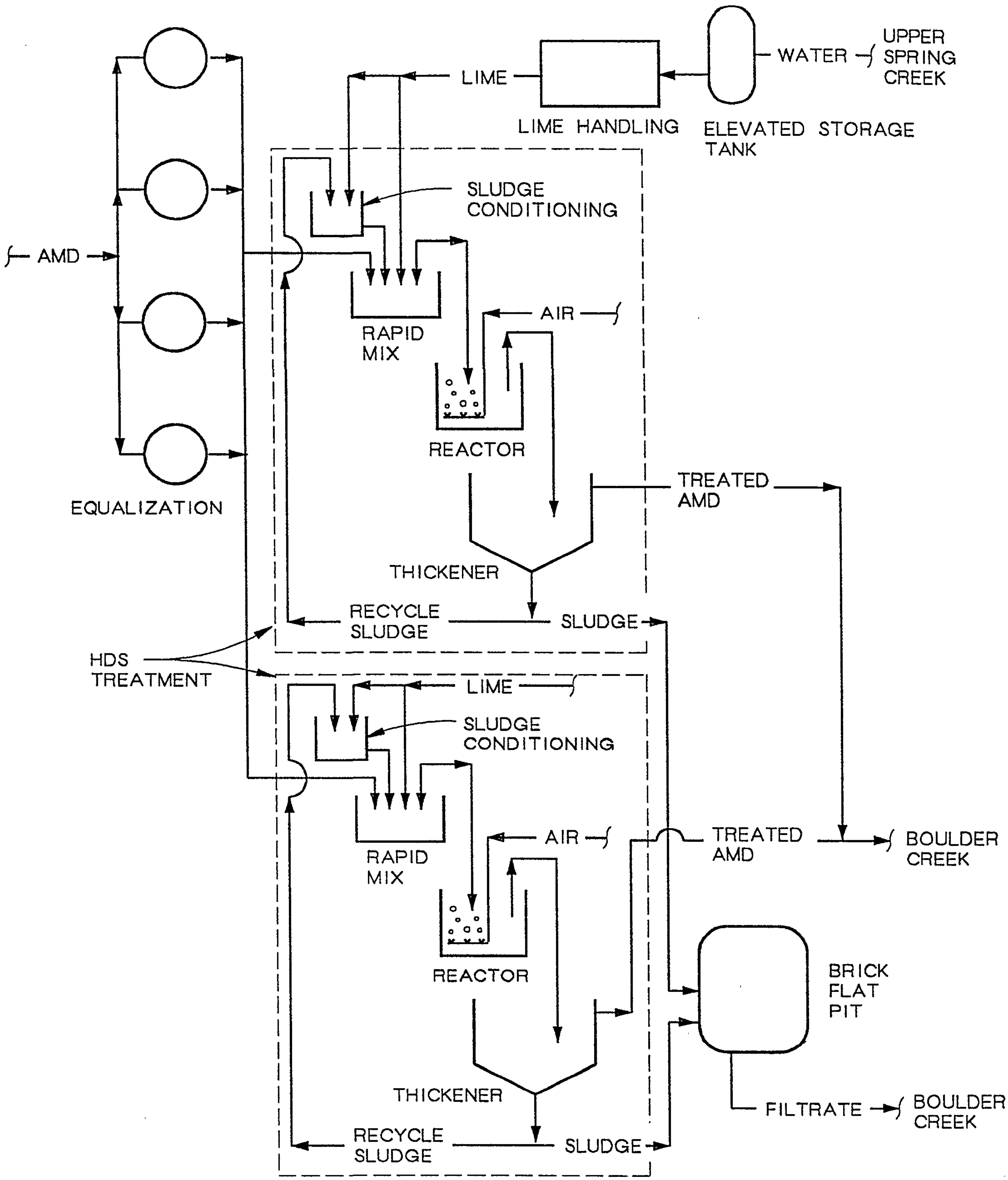

FIGURE TP.03-3
TREATMENT PLANT PROCESS SCHEMATIC AT MINNESOTA FLATS
WET LANDFILL CONCEPT
IRON MOUNTAIN MINE

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Brick Flat Pit

Because a treatment plant at the top of Iron Mountain will be adjacent to the ultimate sludge disposal site in Brick Flat Pit, sludge hauling is not required. Without sludge hauling limitations, it is appropriate for the proposed treatment facilities to rely on the Simple Mix process (with greater sludge production) to treat flows between 300 and the peak observed flow (1,050 gpm, Option 1; 1,300 gpm, Option 2). Therefore, equalization of AMD flows for purposes of reducing peak treatment capacity will not be required. Rather, equalization will be required only to dampen the cyclical flow variations generated by the pumped conveyance system and to allow the treatment plant to operate under uniform hydraulic conditions.

An AMD equalization capacity of 100,000 gallons is proposed for Brick Flat Pit. This will permit winter time equalization of peak pumping rates from the conveyance system. Further, during typically low flow summer conditions, the equalization provided will permit operation of the treatment plant on a scheduled, daytime-only basis. Equalization (assumed multiple tanks) will be situated to provide gravity feed of AMD through the neutralization process. Refer to Table TP.03-2 for estimated detention times provided by the equalization facility at Brick Flat Pit.

Table TP.03-2
Treatment Equalization at Brick Flat Pit
Detention Time Provisions, hours

Flow	Option 1	Option 2
Low	67	42
Average	17	10
Peak	1.6	1.3
Winter	7	4.5

Minnesota Flats

A treatment plant located at Minnesota Flats will primarily receive AMD by gravity pipelines. Flow rates of AMD will therefore be in direct response to flows emanating from the portals. At Minnesota Flats, sludge must first be dried to a haulable consistency prior to transport for disposal in Brick Flat Pit. Because available land for sludge processing and staging is limited, the Simple Mix process will only be used during emergency operation when, for example, critical HDS process equipment has failed. The HDS process shall be relied upon alone to treat all AMD flows, including the peak observed flows. Because it is impractical to design and operate an HDS plant to instantly meet peak flow requirements, the assumed AMD equalization capacity is significantly greater than that for the Brick Flat Pit site.

For the basis of the conceptual design, the HDS plant was comprised of two treatment trains of 300 gpm each. This will provide firm capacity for the winter sustained flows and will normally treat peak flows of up to 600 gpm. Flows in excess of 600 gpm will require equalization prior to treatment. Based upon the peak observed event for the Richmond and Lawson portals (Option 1), this will require 2 million gallons of equalization capacity. This equalization capacity is large enough to accommodate, if desired, only periodic operation during the summer. As in the case of Brick Flat Pit, equalization will be configured to permit gravity flow of AMD through the entire neutralization process.

Lime Feed System

The lime feed system will be comprised primarily of lime storage silos, lime feeders, slakers, the slaker water supply system, and lime slurry feed pumps, if required. The lime feed and slaker water supply systems shall be sized to treat the peak design flows. Specific criteria for treatment capability by site location are as follows:

- **Brick Flat Pit**—Firm capacity must be installed to treat the peak instantaneous AMD flow rate for both Options 1 and 2. This is a normally anticipated treatment occurrence.

- **Minnesota Flats**—Firm capacity must be installed to treat the peak equalized AMD flow rate. Installed capacity must be available to treat the peak instantaneous flow rate utilizing the Simple Mix process as an emergency operation.

Lime Storage and Feeders

Sufficient onsite lime storage is required to ensure continuous plant operation even during interruptions in normal chemical delivery to the facility. As a minimum, a 7-day supply of chemical is required onsite for the most reliable of chemical supply systems and is thus established as a minimum acceptable lime inventory for Minnesota Flats. For a facility located at Brick Flat Pit, an additional 7 days of storage in excess of this base requirement is recommended due to the potential for site access problems caused by poor road conditions during inclement weather. Minimum onsite inventories of lime (as CaO) are listed in Table TP.03-3. Inventories required are based on the sustained winter flow condition.

Table TP.03-3
Minimum Onsite Lime Inventory

Location	Option 1	Option 2
Brick Flat Pit	940 tons	1,500 tons
Minnesota Flats	470 tons	750 tons

Lime feeding and slaking capacity required is largely a function of treatment plant location. The treatment plant at Brick Flat Pit is designed to treat the peak instantaneous AMD flow rate. Because there is no equalization to store peak flows, the lime feed system at Brick Flat Pit is larger than that needed at Minnesota Flats, where extensive equalization is provided. Assuming a lime dosage of 0.4 lb $Ca(OH_2)$/gallon AMD, the lime feeder requirements are as follows:

- **Brick Flat Pit**—For Option 1, firm feeding capacity of 25,000 lb $Ca(OH)_2$/hr (19,000 lb CaO/hr) shall be provided. Under Option 2, firm feeding capacity of 31,000 lb $Ca(OH)_2$/hr (23,500 lb CaO/hr) shall be provided.

- **Minnesota Flats**—For Option 1, firm feeding capacity of 14,400 lb $Ca(OH)_2$/hr (19,000 lb CaO/hr) shall be provided and installed capacity of 25,000 lb $Ca(OH)_2$/hr shall be provided. Under Option 2, firm feeding capacity of 21,600 lb $Ca(OH)_2$/hr (16,400 lb CaO/hr) shall be provided and installed capacity of 31,000 lb $Ca(OH)_2$/hr shall be provided.

Process Water

Water is needed in the AMD neutralization process to both slake and dilute lime. For efficient lime slaking, the water mixed with the lime must have low sulfide concentrations. Therefore, neutralized AMD and filtrate from the Brick Flat Pit sludge disposal landfill will not be of acceptable quality for lime slaking. However, neutralized AMD and filtrate could be used to dilute slaked lime. Assuming a 10 percent lime slurry concentration, by weight $Ca(OH_2)$, the water requirements are shown in Table TP.03-4.

Table TP.03-4
Process Water Requirements

Type	Option 1 Treat 1,050 gpm	Option 2 Treat 1,300 gpm
Slaker Water, gpm	115	140
Dilution Water, gpm	315	390
Total, gpm	430	530

Potential sources of slaker water are Boulder Creek, Slickrock Creek, and Upper Spring Creek. While Boulder Creek is closer to the proposed treatment plant locations, water from Slickrock or Upper Spring Creek may be necessary to augment the Boulder Creek supply. Water pump stations shall be designed to provide firm capacity and system reliability with standby emergency power equipment. Like the AMD pump stations, an access road to the slaker water pump station must be provided. Refer to Figures TP.03-1, -2, and -3 for water pumping and storage schematics.

AMD Neutralization

The neutralization process shall consist of alkali neutralization of the AMD utilizing the HDS process. The process shall incorporate four distinct phases of treatment, consisting of rapid mixing of AMD, neutralizing chemicals, and other reagents; sludge conditioning; reaction and flocculation; and clarification and thickening. The pH of the waste stream shall be elevated to a point that metals are sufficiently removed/oxidized such that clarified supernatant and sludge filtrate will meet the effluent limitations. In no case shall the pH of the neutralized AMD or filtrate be less than 9.

Process recommendations include provisions for the addition of sulfide as part of the HDS system. While specific criteria have not been developed, consideration shall be given to sulfide storage and handling facilities. Sulfide storage criteria shall be similar to the lime storage criteria for each proposed site.

Due to the highly specialized nature of the technology of HDS, and the unique and especially potent characteristics of Iron Mountain Mine AMD, it is strongly recommended that outside consultation from technical experts be employed. The consultants should be uniquely experienced with neutralization of high-strength acidic wastes utilizing the HDS process. Further, the final system configuration should be engineered by a process equipment supplier experienced in the design, fabrication, and operation of equipment utilizing the HDS process. Final system criteria, configuration, and specifications are subject to review and approval by EPA.

Sludge Disposal

Regardless of treatment plant location, neutralized AMD sludge shall be ultimately disposed of in a landfill constructed in Brick Flat Pit. For the treatment plant at Minnesota Flats, sludge drying lagoons shall be provided to dry the sludge to a haulable consistency. If the treatment plant is located near Brick Flat Pit, it is recommended that the neutralization process facilities be located to permit disposal of sludge by gravity. The conceptual design of the landfill is described in Technical Memorandums TP.01a and TP.01b. The AMD treatment plant shall be designed to direct all reactor supernatant and sludge lagoon supernatant or filtrate to Boulder Creek and away from Flat Creek. Should discharge to Flat Creek be contemplated, the discharge must meet all ambient water quality criteria.

Plant Services

Complete plant services including electrical power, potable water, toilet facilities, fire extinguishers and all other safety equipment and provision required by OSHA and all other local requirements shall be supplied.

Treatment Plant Design Summary

The following is an overall summary table of treatment plant design criteria.

Table TP.03-5
Treatment Plant Design Summary

Component	Brick Flat Pit Treatment Plant		Minnesota Flats Treatment Plant	
	Option 1	Option 2	Option 1	Option 2
Treatment Capacity	300 gpm HDS 1,050 gpm Simple Mix		600 gpm HDS (two 300-gpm process trains)	
Equalization	100,000 gallons		2 million gallons	
Lime Storage	940 tons	1,500 tons	470 tons	750 tons
Lime Feed[a]	25,000 lb $Ca(OH)_2$/hr	31,000 lb $Ca(OH)_2$/hr	14,400 lb $Ca(OH)_2$/hr	21,600 lb $Ca(OH)_2$/hr
Slaker Water	115 gpm	140 gpm	115 gpm	140 gpm
Dilution Water	315 gpm	350 gpm	315 gpm	390 gpm
Sludge Disposal	Brick Flat Pit		Lagoons at Minnesota Flats, then Brick Flat Pit	

[a]Refer to the text for special requirements regarding installed lime feed capacity requirements for Minnesota Flats.

References

Nancollas, G. H. and S. T. Liu. 1975. *A Kinetic and Morphological Study of Seeded Growth of Calcium Sulfate Dihydrate in the Presence of Additives.* Journal of Colloid and Interface Science, Vol. 52, No. 3, September 1975.

National Lime Association. 1990. *Lime Handling Application and Storage in Treatment Processes.* Bulletin 213, 6th ed. Arlington, Va.

U.S. EPA, Region IX. 1992. *Public Comment Feasibility Study, Boulder Creek Operable Unit, Iron Mountain Mine, Redding, California.*

Appendix A
Flow Data

Richmond Portal Flow Data

Date	Flow (gpm)	Overall Average Flow (gpd)		Peak Average Flow (gpm)	Peak Flow Duration
12/01/83	434.00	9061920	9061920		
12/30/83	240.00	5875200	5875200		
01/04/84	162.00	1283040	1283040		
01/10/84	117.00	1095120	1095120		
01/17/84	91.10	918288	459144	262.62	47
01/24/84	46.20	498960			
02/01/84	71.50	772200			
02/08/84	71.50	720720			
02/15/84	71.40	719712			
02/22/84	56.10	565488			
02/29/84	63.70	642096			
03/07/84	56.10	565488			
03/14/84	56.10	525096			
03/20/84	86.70	811512			
03/27/84	77.50	781200			
04/03/84	67.40	727920			
04/11/84	60.00	604800			
04/17/84	55.20	516672			
04/24/84	52.10	562680			
05/02/84	45.80	461664			
05/08/84	42.60	429408			
05/16/84	39.60	4790016			
10/23/84	16.60	1995984			
10/30/84	16.60	167328			
11/06/84	16.60	167328			
11/13/84	128.40	1201824	554688		
11/19/84	84.20	788112	788112		
11/26/84	56.90	614520	614520		
12/04/84	54.80	591840	591840		
12/11/84	56.90	573552	573552		
12/18/84	56.90	614520	286776	67.65	35
12/26/84	46.30	11634264			
12/02/85	12.00	3196800			
12/31/85	13.00	439920			
01/18/86	60.00	1339200	561600		
01/31/86	60.00	777600	777600		
02/05/86	167.00	1803600	1803600		
02/15/86	345.00	3229200	3229200		
02/18/86	800.00	3456000	3456000		
02/21/86	464.00	5679360	5679360		
03/07/86	103.00	1557360	1557360		
03/14/86	231.00	2328480	2328480		
03/21/86	187.00	1884960	1884960		
03/28/86	142.00	1431360	1431360		
04/04/86	92.00	927360	927360		
04/11/86	66.00	665280	332640	200.55	83
04/18/86	50.00	504000			
04/25/86	32.00	5091840			
11/25/86	9.00	1445040			
12/04/86	9.00	103680			
12/11/86	8.10	81648			
12/18/86	8.10	163296			
01/08/87	27.00	680400			
01/22/87	25.00	396000			
01/30/87	45.00	388800			
02/03/87	76.00	766080	547200		
02/13/87	46.00	463680	463680		
02/17/87	122.00	966240	966240		
02/24/87	67.00	675360	675360		
03/03/87	43.00	433440	433440		
03/10/87	105.00	1058400	1058400		
03/17/87	164.00	1653120	1653120		
03/24/87	89.00	897120	897120		
03/31/87	77.00	776160	776160		
04/07/87	60.00	604800	302400	85.68	63
04/14/87	52.00	599040			
04/23/87	46.00	529920			
04/30/87	42.00	6713280			
12/01/87	11.00	1766160			
12/09/87	333.00	5034960	3116880		
12/22/87	57.00	902880	902880		
12/31/87	46.00	529920	529920		
01/07/88	40.00	403200	403200		
01/14/88	103.00	1038240	1038240		
01/21/88	84.00	846720	846720		
01/28/88	58.00	542880	542880		
02/03/88	62.00	624960	624960		
02/11/88	62.00	714240	357120	90.74	64
02/19/88	48.00	760320			
03/04/88	36.00	544320			
03/11/88	34.00	342720			
03/18/88	31.00	580320			
04/06/88	24.00	587520			
04/21/88	23.00	480240			
05/05/88	29.00	1148400			
06/15/88	34.00	1517760			
07/06/88	28.00	604800			
07/15/88	26.00	917280			
08/24/88	19.00	1600560			
11/09/88	11.00	681120			
11/18/88	21.00	317520			
11/30/88	37.50	675000			
12/13/88	37.00	932400			
01/04/89	35.00	730800			
01/11/89	35.00	378000			
01/19/89	40.00	403200			
01/25/89	15.50	122760			
01/30/89	17.00	146880			
02/06/89	38.00	410400			
02/14/89	45.00	518400			
02/22/89	45.50	655200			
03/06/89	32.00	437760			
03/13/89	200.00	2016000	1008000		
03/20/89	140.00	1411200	1411200		
03/27/89	141.00	1421280	1421280		
04/03/89	143.00	1441440	1441440		
04/10/89	94.00	947520	947520		
04/17/89	60.00	604800	302400	129.60	35
04/24/89	45.00	453600			
05/01/89	40.00	604800			
05/15/89	35.00	1108800			
06/14/89	35.00	1512000			
07/14/89	23.00	1059840			
08/17/89	19.00	902880			
09/18/89	17.00	832320			
10/24/89	23.00	844560			
11/08/89	27.00	427680			
11/15/89	27.00	252720			
11/21/89	26.00	262080			
11/29/89	22.00	237600			
12/06/89	19.00	191520			
12/13/89	19.00	191520			
12/20/89	20.00	216000			
12/28/89	16.00	161280			
01/03/90	15.00	140400			
01/10/90	15.00	140400			
01/16/90	30.00	302400			
01/24/90	34.00	391680			
02/01/90	30.00	302400			
02/07/90	29.20	273312			
02/14/90	29.00	292320			
02/21/90	28.20	304560			
03/01/90	28.70	289296			
03/07/90	28.90	270504			
03/14/90	30.40	306432			
03/21/90	30.20	304416			
03/28/90	28.20	284256			
04/04/90	26.00	262080			
04/11/90	24.20	243936			
04/18/90	23.10	465696			
05/09/90	19.00	560880			
05/29/90	134.00	2122560	192960		
05/31/90	76.00	875520	875520		
06/14/90	57.00	615600	615600		
6/15/90	63.00	90720	90720		
6/16/90	61.00	87840	87840		
6/17/90	62.00	89280	89280		
6/18/90	62.00	89280	89280		
6/19/90	60.00	86400	43200	68.93	21
6/20/90	56.00	80640			
6/21/90	57.00	82080			
6/22/90	57.00	82080			
6/23/90	55.00	79200			
6/24/90	57.00	82080			
6/25/90	55.00	79200			
6/26/90	54.00	77760			
6/27/90	55.00	79200			
6/28/90	56.00	80640			
6/29/90	56.00	80640			
6/30/90	56.00	80640			
7/1/90	56.00	80640			
7/2/90	42.00	60480			
7/3/90	40.00	57600			
7/4/90	40.00	57600			
7/5/90	40.00	57600			
7/6/90	39.00	56160			
7/7/90	39.00	56160			

7/8/90	39.00	56160						
7/9/90	41.00	59040						
7/10/90	35.00	50400						
7/11/90	39.00	56160						
7/12/90	39.00	56160						
7/13/90	39.00	56160						
7/14/90	39.00	56160						
7/15/90	39.00	56160						
7/16/90	39.00	56160						
7/17/90	38.00	54720						
7/18/90	38.00	54720						
7/19/90	37.00	53280						
7/20/90	37.00	53280						
7/21/90	37.00	53280						
7/22/90	38.00	54720						
7/23/90	38.00	54720						
7/24/90	36.00	51840						
7/25/90	36.00	51840						
7/26/90	35.00	50400						
7/27/90	35.00	50400						
7/28/90	35.00	50400						
7/29/90	35.00	50400						
7/30/90	34.00	48960						
7/31/90	34.00	48960						
8/1/90	35.00	50400						
8/2/90	35.00	50400						
8/3/90	35.00	50400						
8/4/90	35.00	50400						
8/5/90	35.00	50400						
8/6/90	35.00	50400						
8/7/90	32.00	46080						
8/8/90	35.00	50400						
8/9/90	34.00	48960						
8/10/90	35.00	50400						
8/11/90	35.00	50400						
8/12/90	35.00	50400						
8/13/90	35.00	50400						
8/14/90	34.00	48960						
8/15/90	34.00	48960						
8/16/90	31.00	44640						
8/17/90	31.00	44640						
8/18/90	34.00	48960						
8/19/90	34.00	48960						
8/20/90	32.00	46080						
8/21/90	30.00	43200						
8/22/90	25.00	36000						
8/23/90	26.00	37440						
8/24/90	25.00	36000						
8/25/90	26.00	37440						
8/26/90	25.00	36000						
8/27/90	25.00	36000						
8/28/90	25.00	36000						
8/29/90	23.00	33120						
8/30/90	23.00	33120						
8/31/90	24.00	34560						
9/1/90	24.00	34560						
9/2/90	24.00	34560						
9/3/90	25.00	36000						
9/4/90	25.00	36000						
9/5/90	25.00	36000						
9/6/90	25.00	36000						
9/7/90	24.00	34560						
9/8/90	25.00	36000						
9/9/90	25.00	36000						
9/10/90	25.00	36000						
9/11/90	25.00	36000						
9/12/90	25.00	36000						
9/13/90	25.00	36000						
9/14/90	26.00	37440						
9/15/90	26.00	37440						
9/16/90	24.00	34560						
9/17/90	25.00	36000						
9/18/90	25.00	36000						
9/19/90	23.00	33120						
9/20/90	23.00	33120						
9/21/90	23.00	33120						
9/22/90	23.00	149040						
9/30/90	23.00	960480						
11/19/90	14.00	665280						
12/5/90	12.00	198720						
12/12/90	12.00	190080						
12/27/90	11.00	213840						
1/8/91	11.00	205920						
1/22/91	11.00	182160						
1/31/91	11.00	118800						
2/6/91	11.00	213840						
2/27/91	14.00	231840						

3/1/91	14.50	41760						
3/3/91	14.10	30456						
3/4/91	14.90	21456						
3/5/91	13.20	19008						
3/6/91	15.10	21744						
3/7/91	17.40	25056						
3/8/91	21.00	60480						
3/11/91	23.50	67680						
3/12/91	24.70	35568						
3/13/91	25.50	36720						
3/14/91	26.60	38304						
3/15/91	26.80	77184						
3/18/91	30.00	86400						
3/19/91	31.10	44784						
3/20/91	31.20	44928						
3/21/91	31.50	45360						
3/22/91	33.00	95040						
3/25/91	44.00	126720						
3/26/91	74.00	106560	53280					
3/27/91	82.90	119376	119376					
3/28/91	76.80	110592	110592					
3/29/91	76.70	220896	220896					
4/1/91	87.30	251424	251424					
4/2/91	117.50	169200	169200					
4/3/91	135.30	194832	194832					
4/4/91	154.40	222336	222336					
4/5/91	137.10	394848	394848					
4/8/91	111.00	319680	319680					
4/9/91	97.00	139680	139680					
4/10/91	90.40	130176	130176					
4/11/91	77.00	110880	110880					
4/12/91	71.80	206784	51696	101.67	17			
4/15/91	58.90	169632						
4/16/91	58.60	84384						
4/17/91	54.20	78048						
4/18/91	51.00	73440						
4/19/91	51.30	73872						
4/20/91	49.10	70704						
4/21/91	49.90	71856						
4/22/91	52.20	75168						
4/23/91	50.70	73008						
4/24/91	47.70	68688						
4/25/91	48.10	2597400						
7/8/91	21.00	1254960						
7/17/91	20.30	233856						
7/24/91	18.00	194400						
8/1/91	18.40	198720						
8/8/91	17.30	186840						
8/16/91	17.00	146880						
8/20/91	15.90	57240						
8/21/91	16.00	92160						
8/28/91	15.10	163080						
9/5/91	14.70	158760						
9/12/91	14.20	132912						
9/18/91	13.50	136080						
9/26/91	14.00	161280						
10/4/91	13.30	143640						
10/11/91	13.00	121680						
10/17/91	12.40	107136						
10/23/91	12.00	60480						
10/24/91	11.70	75816						
11/1/91	11.00	102960						
11/6/91	11.00	55440						
11/8/91	11.30	56952						
11/13/91	12.00	60480						
11/15/91	10.80	54432						
11/20/91	11.00	55440						
11/22/91	10.30	51912						
11/27/91	10.30	96408						
12/5/91	10.10	101808						
12/11/91	11.00	55440						
12/12/91	10.50	15120						
12/13/91	10.50	30240						
12/16/91	10.40	29952						
12/17/91	10.00	14400						
12/18/91	10.30	14832						
12/19/91	10.50	15120						
12/20/91	10.00	28800						
12/23/91	9.80	28224						
12/24/91	9.50	13680						
12/25/91	9.90	14256						
12/26/91	9.70	13968						
12/27/91	9.80	28224						
12/30/91	9.60	27648						
12/31/91	9.80	14112						
1/1/92	9.70	13968						
1/2/92	9.90	14256						

1/3/92	10.30	29664						
1/6/92	12.90	37152						
1/7/92	13.30	19152						
1/8/92	15.50	22320						
1/9/92	19.00	27360						
1/10/92	21.00	60480						
1/13/92	23.10	66528						
1/14/92	23.40	33696						
1/15/92	24.30	34992						
1/16/92	25.10	36144						
1/17/92	25.80	74304						
1/20/92	23.30	67104						
1/21/92	22.00	31680						
1/22/92	22.00	31680						
1/23/92	21.90	31536						
1/24/92	22.20	63936						
1/27/92	22.20	63936						
1/28/92	21.90	31536						
1/29/92	21.90	31536						
1/30/92	21.90	31536						
1/31/92	21.90	63072						
2/3/92	20.80	59904						
2/4/92	20.80	29952						
2/5/92	19.70	28368						
2/6/92	19.70	70920						
2/10/92	19.50	70200						
2/11/92	20.50	29520						
2/12/92	21.80	31392						
2/13/92	54.60	78624	39312					
2/14/92	116.00	167040	167040					
2/15/92	187.00	403920	403920					
2/17/92	263.00	568080	568080					
2/18/92	203.70	293328	293328					
2/19/92	205.80	296352	296352					
2/20/92	285.20	410688	410688					
2/21/92	277.60	799488	799488					
2/24/92	228.00	656640	656640					
2/25/92	187.60	270144	270144					
2/26/92	165.00	237600	237600					
2/27/92	142.60	205344	205344					
2/28/92	120.80	173952	173952					
2/29/92	111.60	241056	241056					
3/2/92	98.40	212544	212544					
3/3/92	88.60	127584	127584					
3/4/92	87.00	125280	125280					
3/5/92	81.40	117216	117216					
3/6/92	82.50	237600	237600					
3/9/92	102.20	294336	294336					
3/10/92	104.30	150192	150192					
3/11/92	100.90	145296	145296					
3/12/92	94.70	136368	136368					
3/13/92	91.60	263808	263808					
3/16/92	172.30	496224	496224					
3/17/92	360.00	518400	518400					
3/18/92	412.00	593280	593280					
3/19/92	300.00	432000	432000					
3/20/92	280.00	806400	806400					
3/23/92	218.00	627840	627840					
3/24/92	215.00	309600	309600					
3/25/92	211.00	303840	303840					
3/26/92	178.80	257472	257472					
3/27/92	154.00	443520	443520					
3/30/92	120.00	345600	345600					
3/31/92	115.10	165744	165744					
4/1/92	114.00	164160	164160					
4/2/92	108.20	155808	155808					
4/3/92	98.50	283680	283680					
4/6/92	85.50	246240	246240					
4/7/92	85.30	122832	122832					
4/8/92	83.10	119664	119664					
4/9/92	81.00	116640	116640					
4/10/92	81.40	117216	117216					
4/11/92	81.70	176472	176472					
4/13/92	84.30	182088	182088					
4/14/92	83.70	120528	120528					
4/15/92	83.80	120672	120672					
4/16/92	111.00	159840	159840					
4/17/92	92.00	264960	264960					
4/20/92	109.00	313920	313920					
4/21/92	115.00	165600	165600					
4/22/92	137.00	197280	197280					
4/23/92	104.00	149760	149760					
4/24/92	104.00	299520	299520					
4/27/92	89.50	257760	257760					
4/28/92	86.30	124272	124272					
4/29/92	83.10	119664	119664					
4/30/92	80.00	115200	115200					

5/1/92	80.30	231264	231264					
5/4/92	78.40	225792	225792					
5/5/92	74.60	107424	107424					
5/6/92	71.10	102384	102384					
5/7/92	71.00	102240	102240					
5/8/92	71.00	204480	204480					
5/11/92	71.70	206496	206496					
5/12/92	67.50	97200	97200					
5/13/92	64.70	93168	93168					
5/14/92	65.60	94464	94464					
5/15/92	60.00	172800	172800					
5/18/92	60.00	172800	172800					
5/19/92	63.00	90720	90720					
5/20/92	60.00	86400	43200	128.23	97			
5/21/92	57.60	1161216						
6/17/92	37.00	719280						
Overall Average (gpm)=			44.50	(Drought Conditions- Use 60 gpm for Design)				
Peak Winter Average(gpm)=			126.19					
Low Flow Condition (gpm)=			10.00					
Peak Design Flow (gpm)=			800.00					

Lawson Portal Flow Measurements

DATE	FLOW (gpm)	Overall Average Flow (gpd)		Average Peak Winter Flow (gpm)	Peak Flow Duration		
09/26/83	32	3709440					
12/01/83	222	15184800	4635360				
12/30/83	91	2230128	2230128				
01/04/84	76	601920	601920				
01/10/84	79	739440	739440				
01/17/84	66	665280	665280				
01/24/84	68	734400	342720	118.50	54		
02/01/84	47	502200					
02/08/84	47	468720					
02/15/84	46	465696					
02/22/84	46	465696					
02/29/84	40	399168					
03/07/84	46	465696					
03/14/84	46	432432					
03/20/84	46	432432					
03/27/84	46	465696					
04/03/84	47	508680					
04/11/84	40	403200					
04/17/84	39	362232					
04/24/84	36	390960					
05/02/84	34	337680					
05/08/84	34	338688					
05/16/84	32	3822336					
10/23/84	27	3294576					
10/30/84	27	276192					
11/06/84	27	276192					
11/13/84	27	256464					
11/19/84	40	370656					
11/26/84	40	313632					
11/30/84	46	266688					
12/04/84	46	366696					
12/11/84	46	466704					
12/18/84	46	500040					
12/26/84	40	9950688					
12/02/85	18	4795200					
12/31/85	19	642960					
01/18/86	21	468720					
01/31/86	34	440640					
02/05/86	87	939600	626400				
02/15/86	78	730080	730080				
02/18/86	236	1019520	1019520				
02/21/86	168	2056320	2056320				
03/07/86	66	997920	997920				
03/14/86	102	1028160	1028160				
03/21/86	102	1028160	1028160				
03/28/86	83	836640	836640				
04/04/86	75	756000	378000	104.18	58		
04/11/86	58	584640					
04/18/86	50	504000					
04/25/86	43	6842160					
11/25/86	19	3050640					
12/04/86	20	230400					
12/11/86	18	181440					
12/18/86	18	362880					
01/08/87	13	327600					
01/22/87	13	205920					
01/30/87	20	172800					
02/03/87	13	131040					
02/13/87	18	181440					
02/17/87	23	182160					
02/24/87	23	231840					
03/03/87	23	231840					
03/10/87	36	362880					
03/17/87	66	665280					
03/24/87	36	362880					
03/31/87	36	362880					
04/07/87	29	292320					
04/14/87	29	334080					
04/23/87	23	264960					
04/30/87	29	4635360					
12/01/87	18	2890080					
12/09/87	38	567000					
12/22/87	35	907200					
01/14/88	47	1015200					
01/21/88	55	554400					
01/28/88	45	421200					
02/03/88	38	378000					
02/11/88	35	403200					
02/19/88	32	506880					
03/04/88	27	544320					
03/18/88	25	594000					
04/06/88	24	587520					
04/21/88	27	563760					
05/05/88	23	910800					
06/15/88	30	1533600					
07/15/88	27	1360800					
08/24/88	23	1937520					
11/09/88	19	1176480					
11/18/88	17	257040					
11/30/88	27	486000					
12/13/88	25	756000					
01/11/89	18	479520					
01/19/89	23	226800					
01/25/89	23	178200					
01/30/89	28	241920					
02/06/89	27	291600					
02/14/89	25	288000					
02/22/89	25	360000					
03/06/89	25	342000					
03/13/89	111	1118880	559440				
03/20/89	67	675360	675360				
03/27/89	69	695520	695520				
04/03/89	75	756000	378000	76.33	21		
04/10/89	52	524160					
04/17/89	41	413280					
04/24/89	36	362880					
05/01/89	31	468720					
05/15/89	29	918720					
06/14/89	25	1080000					
07/14/89	19	875520					
08/17/89	19	902880					
09/18/89	18	881280					
10/24/89	18	660960					
11/08/89	21	332640					
11/15/89	20	187200					
11/21/89	21	317520					
12/06/89	20	316800					
12/13/89	20	201600					
12/20/89	18	194400					
12/28/89	18	181440					
01/03/90	17	159120					
01/10/90	20	182520					
01/16/90	23	231840					
01/24/90	27	311040					
02/01/90	23	231840					
02/07/90	21	198432					
02/14/90	20	197568					
02/21/90	20	210600					
03/01/90	21	211680					
03/07/90	23	211536					
03/14/90	23	227808					
03/21/90	24	245952					
03/28/90	24	236880					
04/04/90	24	243936					
04/11/90	21	211680					
04/18/90	19	383040					
05/09/90	19	560880					
05/29/90	110	1742400	158400				
05/31/90	73	840960	105120	91.50	2		
06/14/90	44	3769920					
9/27/90	20.7	1699056					
10/6/90	20.1	217080					
10/12/90	20	230400					
10/22/90	17.4	212976					
10/29/90	16.2	151632					
11/4/90	18.5	146520					
11/9/90	19.5	182520					
11/17/90	16.1	197064					
11/26/90	16.8	157248					
11/30/90	18.9	81648					
12/2/90	15.4	33264					
12/3/90	15.4	22176					
12/4/90	15.6	22464					
12/5/90	18.9	27216					
12/6/90	18.2	26208					
12/7/90	18.8	54144					
12/10/90	20.9	60192					
12/11/90	18.8	27072					
12/12/90	18.4	26496					
12/13/90	17.1	24624					
12/14/90	17.8	51264					
12/17/90	18.6	53568					
12/18/90	18	25920					
12/19/90	18.9	27216					
12/20/90	18.6	26784					
12/21/90	14	20160					
12/22/90	17.5	25200					
12/23/90	16.1	46368					

12/26/90	18.2	52416					
12/27/90	17.8	25632					
12/28/90	17.6	50688					
12/31/90	17.5	50400					
1/1/91	17.6	25344					
1/2/91	16.8	24192					
1/3/91	13.5	19440					
1/4/91	14.1	40608					
1/7/91	17.5	50400					
1/8/91	17.5	25200					
1/9/91	18.2	26208					
1/10/91	17.3	24912					
1/11/91	18.2	52416					
1/14/91	17.5	50400					
1/15/91	18	25920					
1/16/91	18	25920					
1/17/91	18	25920					
1/18/91	18	51840					
1/21/91	14.6	42048					
1/22/91	14.9	21456					
1/23/91	13.8	19872					
1/24/91	14.5	20880					
1/25/91	14.2	40896					
1/28/91	14.4	41472					
1/29/91	15.9	22896					
1/30/91	15.8	22752					
1/31/91	15.8	22752					
2/1/91	15.3	44064					
2/4/91	18.6	53568					
2/5/91	16.8	24192					
2/6/91	16.2	23328					
2/7/91	17.3	24912					
2/8/91	16.2	46656					
2/11/91	15.7	45216					
2/12/91	15.9	22896					
2/13/91	17	24480					
2/14/91	16.1	23184					
2/15/91	15	43200					
2/18/91	15.5	44640					
2/19/91	16.2	23328					
2/20/91	15.7	22608					
2/21/91	15.5	22320					
2/22/91	15.7	45216					
2/25/91	15.6	44928					
2/26/91	16.1	23184					
2/27/91	16.8	24192					
2/28/91	16.1	23184					
3/1/91	22	47520					
3/3/91	18	38880					
3/4/91	24.7	35568					
3/5/91	15	21600					
3/6/91	18	25920					
3/7/91	17.3	24912					
3/8/91	17	48960					
3/11/91	15.3	44064					
3/12/91	24.7	35568					
3/13/91	18.1	26064					
3/14/91	19.6	28224					
3/15/91	16.7	48096					
3/18/91	20.4	58752					
3/19/91	18.8	27072					
3/20/91	21.9	31536					
3/21/91	20	72000					
3/25/91	28.6	144144					
3/28/91	41.1	295920					
4/4/91	37.3	349128					
4/10/91	45.5	425880					
4/17/91	39.1	337824					
4/22/91	32.7	141264					
4/23/91	32.7	47088					
4/24/91	31.6	45504					
4/25/91	31	44640					
4/26/91	31.6	91008					
4/29/91	30	86400					
4/30/91	28.1	161856					
5/7/91	24.8	142848					
5/8/91	28.6	144144					
5/14/91	25	288000					
5/24/91	23.3	234864					
5/28/91	23.4	219024					
6/6/91	22.5	259200					
6/13/91	21.2	198432					
6/19/91	20.7	208656					
6/27/91	19.8	270864					
7/8/91	20.2	290880					
7/17/91	20.2	232704					
7/24/91	20	216000					

8/1/91	18.2	196560					
8/8/91	17.8	192240					
8/16/91	18	168480					
8/21/91	22	190080					
8/28/91	17.6	190080					
9/5/91	19.3	208440					
9/12/91	19.1	178776					
9/18/91	18	181440					
9/26/91	18.1	456120					
10/23/91	17	440640					
11/1/91	19	191520					
11/6/91	17	85680					
11/8/91	31.6	204768					
11/15/91	19.2	1423872					
2/19/92	40	2793600					
2/20/92	40	144000					
2/24/92	101	363600	72720				
2/25/92	90	129600	129600				
2/26/92	80	345600	345600				
3/2/92	65	327600	327600				
3/4/92	61	307440	87840	74.33	9		
3/9/92	55	237600					
3/10/92	38	54720					
3/11/92	58	250560	208800				
3/16/92	162	699840	699840				
3/17/92	162	233280	233280				
3/18/92	186	267840	267840				
3/19/92	135	680400	680400				
3/25/92	100	504000	504000				
3/26/92	73	105120	105120				
3/27/92	70	201600	201600				
3/30/92	60	172800	129600	110.76	19		
3/31/92	51	73440					
4/1/92	61	87840					
4/2/92	54	77760					
4/3/92	58	167040					
4/6/92	49.1	141408					
4/7/92	46	66240					
4/8/92	60	86400					
4/9/92	47	67680					
4/10/92	44	126720					
4/13/92	50	144000					
4/14/92	47	67680					
4/15/92	43	61920					
4/16/92	51	73440					
4/17/92	46	132480					
4/20/92	54	155520					
4/21/92	51	73440					
4/22/92	56	80640					
4/23/92	54	77760					
4/24/92	54	233280					
4/29/92	60	302400					
5/1/92	46	165600					
5/4/92	46	132480					
5/5/92	46	66240					
5/6/92	43	61920					
5/7/92	43	61920					
5/8/92	43	123840					
5/11/92	40	115200					
5/12/92	41	59040					
5/13/92	39	168480					
5/18/92	35	176400					
5/20/92	34	73440					
5/21/92	34	24480					
Overall Average Flow (gpm)=			34.48	(Drought Conditions- use 40 gpm for design)			
Overall Peak Winter Average=			95.94				
Low Flow Condition (gpm) =			15				
Peak Design Flow (gpm) =			250				

Old Mine/No. 8 Flow							
Winter Period Runs December 1 through June 30 = 212 days							
				Winter Average Flow(gpm)	Peak Flow Average (gpm)		Overall Average Flow(gpd)
Date	pH	Flow (gpm)					
12/1/78		10					
3/1/79		70					
6/1/79		64					
8/5/80		50					
8/28/80		50					
10/1/80		37					1750320
12/5/80		40	1411200				3052800
1/15/81	2.40	77	2716560				2716560
1/23/81	2.70	44	1362240				1362240
2/27/81		78	2751840		2751840		2751840
3/13/81	2.40	89	1345680		1345680		1345680
3/20/81		83	1015920		1015920		1015920
3/30/81	2.70	94	1150560		1150560		1150560
4/6/81	2.61	90	1620000		1620000		1620000
4/24/81	2.60	90	1490400		1490400		1490400
4/29/81	2.50	90	1684800		1684800		1684800
5/20/81	2.50	103	2743920		2743920		2743920
6/5/81	2.49	91	1375920		1375920		1375920
6/10/81	2.50	84	604800		604800		604800
6/15/81	2.50	74	1864800	75.79	1971360	114.17	1971360
7/17/81		75					2808000
8/6/81	2.60	50					2736000
10/1/81	2.90	40					2505600
11/1/81		67			2894400		2894400
11/30/81		67			1833120		1833120
12/9/81	3.10	88	1393920		950400		950400
12/15/81	2.40	88	887040		887040		887040
12/23/81	2.30	100	1080000		1080000		1080000
12/30/81		107	4237200		4237200		4237200
2/16/82	2.60	125	5130000		5130000		5130000
2/25/82	2.20	125	1620000		1620000		1620000
3/6/82	2.50	175	1764000		1764000		1764000
3/11/82	2.50	200	5616000		5616000		5616000
4/14/82	2.50	172	5696640		5696640		5696640
4/26/82	2.20	186	2276640		2276640		2276640
5/1/82	2.70	124	11160000	133.85	9106560	165.33	9106560
8/6/82	2.80	73					6937920
9/10/82	2.80	63					3311280
10/18/82	3.00	62					2612520
11/8/82	2.80	65					2152800
12/3/82	2.80	56	1128960				1975680
12/27/82	2.60	80	2361600		2361600		2361600
1/13/83	2.60	80	1324800		1324800		1324800
1/19/83	2.80	80	633600		633600		633600
1/24/83	2.90	96	622080		622080		622080
1/28/83	2.10	150	2376000		2376000		2376000
2/15/83	2.00	192	9123840		9123840		9123840
4/4/83	2.30	210	7711200		7711200		7711200
4/7/83		212	3816000		3816000		3816000
4/29/83	2.50	230	9936000		9936000		9936000
6/6/83	2.60	177	5862240		5862240		5862240
6/14/83	2.30	175	5040000	163.58	4410000	197.97	4410000
7/11/83	2.50	97					5098320
8/26/83	2.40	61					3513600
9/29/83	2.85	68					3427200
11/4/83	2.80	41			1859760		1859760
12/1/83	1.15	679	7333200		20532960		20532960
12/16/83		231	4823280		4823280		4823280
12/30/83	2.55	81	1108080		1108080		1108080
1/4/84	2.40	136	1078704		1078704		1078704
1/10/84	2.20	98	919152		919152		919152
1/17/84	2.15	109	1022112		1022112		1022112
1/23/84		120	604800		604800		604800
1/24/84	2.35	98	636336		636336		636336
2/1/84	2.20	93	599400		599400		599400
2/2/84		93	468720		468720		468720
2/8/84	2.55	110	1029600		1029600		1029600
2/15/84	1.70	110	1108800		1108800		1108800
2/22/84	2.35	101	1018080		1018080		1018080
2/29/84	2.20	103	1038240		1038240		1038240
3/7/84	2.52	92	927360		927360		927360
3/14/84	2.35	84	786240		786240	209.72	786240
3/20/84	2.45	84	786240				786240
3/27/84	2.45	80	806400				806400
4/3/84	2.40	82	472320				472320
4/4/84		82	472320				472320
4/11/84	2.30	76	438912				438912
4/12/84		76	328320				328320
4/17/84	2.20	73	317088				317088
4/18/84		73	367920				367920
4/24/84	2.35	73	735840				735840

5/2/84	3.10	65	655200				655200
5/8/84	2.30	66	665280				665280
5/16/84	2.25	61	1361520				1361520
6/8/84		55	2653200	113.22			2296800
7/13/84	2.80	52					1535040
7/19/84		50					1440000
8/22/84		40					1353600
9/4/84	2.70	39					814320
9/20/84		40					1065600
10/11/84		45					1069200
10/23/84	2.50	40					426600
10/26/84	2.74	35					176400
10/30/84	2.10	40					312840
11/6/84	2.30	40					227520
11/7/84		50					252000
11/13/84	2.67	52					449280
11/19/84	2.35	43					401544
11/26/84	2.33	46					300024
11/28/84		60					216000
12/1/84	2.90	70	151200				302400
12/4/84	2.41	57	245808				245808
12/7/84	2.50	80	403200				403200
12/11/84	2.33	61	479952				479952
12/18/84	2.32	64	695520				695520
12/26/84	2.20	64	788256		788256		788256
1/4/85	2.70	95	1094400		1094400		1094400
1/11/85	2.90	100	1008000		1008000		1008000
1/18/85	2.90	110	1108800		1108800		1108800
1/25/85	2.80	115	1987200		1987200		1987200
2/11/85	2.47	95	1436400		1436400		1436400
2/15/85	2.70	90	712800		712800		712800
2/22/85	2.90	90	777600		777600		777600
2/27/85	2.90	80	806400		806400	107.14	806400
3/8/85		50	576000				576000
3/15/85		50	432000				432000
3/20/85	2.57	39	196560				196560
3/22/85		45	615600				615600
4/8/85	3.00	45	1911600				1911600
5/20/85	2.70	40	1612800				1612800
6/3/85		35	403200				403200
6/5/85	2.90	40	1497600	62.04			1180800
7/14/85	2.90	37					1944720
8/17/85	3.00	30					1252800
9/10/85	2.70	28					685440
9/20/85	3.50	25					990000
11/4/85	3.50	20					1051200
12/2/85	2.76	23	115920				546480
12/7/85	2.90	20	201600				201600
12/16/85	2.70	23	215280				215280
12/20/85	3.00	25	198000				198000
12/27/85	3.10	25	198000				198000
12/31/85		25	144000				144000
1/4/86	3.00	25	180000				180000
1/10/86	3.00	25	234000				234000
1/17/86	3.20	27	155520				155520
1/18/86	2.73	28	141120				141120
1/24/86	3.00	30	280800				280800
1/31/86		30	216000				216000
2/3/86	3.00	25	90000				90000
2/5/86		38	191520				191520
2/10/86	3.00	30	194400				194400
2/14/86	3.00	50	180000				180000
2/15/86		57	164160				164160
2/18/86		64	230400				230400
2/20/86	3.00	60	129600				129600
2/21/86		83	478080				478080
2/28/86	3.00	60	604800		604800		604800
3/7/86		100	1008000		1008000		1008000
3/14/86		100	1008000		1008000		1008000
3/21/86		115	1159200		1159200		1159200
3/28/86		117	1179360		1179360		1179360
4/4/86		115	1159200		1159200		1159200
4/11/86		130	1310400		1310400		1310400
4/18/86		107	1078560		1078560		1078560
4/25/86		98	705600		705600		705600
4/28/86	2.90	70	352800		352800		352800
5/2/86	2.90	70	907200		907200	115.44	907200
5/16/86	3.00	65	1918800				1918800
6/12/86	3.50	55	2494800	61.67			5068800
9/21/86	3.00	25					2124000
10/8/86	3.00	25					990000
11/15/86	3.00	20					691200
11/25/86		23					314640
12/4/86		22	205920				253440
12/11/86		21	211680				211680
12/18/86		20	129600				129600
12/20/86	3.50	19	177840				177840

12/31/86	3.00	18	220320				220320
1/6/87	2.50	19	109440				109440
1/8/87		19	109440				109440
1/14/87	3.50	19	191520				191520
1/22/87		22	253440				253440
1/30/87		21	181440				181440
2/3/87		18	142560				142560
2/10/87	3.50	20	144000				144000
2/13/87		23	115920				115920
2/17/87		24	190080				190080
2/24/87		29	292320				292320
3/3/87		33	332640				332640
3/10/87		38	383040				383040
3/17/87		40	403200				403200
3/24/87		45	453600				453600
3/31/87		49	493920				493920
4/7/87		36	362880				362880
4/14/87		48	552960				552960
4/23/87		50	576000				576000
4/30/87		48	4458240	35.02			7672320
12/1/87	2.54	16	92160				2568960
12/9/87	3.03	23	347760				347760
12/22/87		33	855360				855360
1/14/88	2.31	41	885600				885600
1/21/88	2.54	47	473760				473760
1/28/88	2.49	51	477360				477360
2/3/88	2.47	52	524160				524160
2/11/88	2.50	51	587520				587520
2/19/88	2.48	50	792000				792000
3/4/88	2.53	45	907200				907200
3/18/88	1.91	42	997920				997920
4/6/88	2.42	34	832320				832320
4/21/88	2.27	40	835200				835200
5/5/88	2.64	35	1386000				1386000
6/15/88	2.53	44	2185920	39.90			2249280
7/15/88	2.64	40					2016000
8/24/88	2.65	34					2864160
11/9/88	2.68	21					1285200
11/17/88	2.78	24					155520
11/18/88	2.68	25					234000
11/30/88	2.77	35					478800
12/7/88	3.20	34	440640				318240
12/13/88		34	856800				856800
1/11/89	2.74	37	985680				985680
1/19/89	2.59	39	393120				393120
1/25/89	2.67	43	340560				340560
1/30/89	2.47	42	362880				362880
2/6/89	2.34	39	421200				421200
2/14/89	2.54	45	518400				518400
2/22/89	2.34	45	648000				648000
3/6/89	2.49	40	489600				489600
3/11/89	2.60	50	252000				252000
3/13/89	2.43	50	324000		324000		324000
3/20/89	2.30	70	705600		705600		705600
3/27/89	2.24	100	1008000		1008000		1008000
4/3/89	2.35	96	967680		967680		967680
4/10/89	3.38	86	866880		866880		866880
4/17/89	2.07	90	907200		907200		907200
4/24/89	2.44	79	796320		796320		796320
5/1/89	2.20	72	1088640		1088640		1088640
5/15/89	2.33	68	2154240		2154240	97.21	2154240
6/14/89	2.48	52	2246400	54.95			2246400
7/14/89	2.49	39					1774080
8/17/89	2.15	30					1425600
9/18/89	2.42	27					1321920
10/24/89	1.75	22					807840
11/8/89	2.65	28					443520
11/15/89	2.39	30					280800
11/21/89	2.38	29					438480
12/6/89	2.01	28	342720				443520
12/13/89	2.42	28	282240				282240
12/20/89	2.54	28	302400				302400
12/28/89	2.47	25	252000				252000
1/3/90	2.36	25	234000				234000
1/10/90	2.4	26	243360				243360
1/16/90	2.59	30	302400				302400
1/24/90	2.25	28	322560				322560
2/1/90	1.97	30	302400				302400
2/7/90	2.49	30.2	282672				282672
2/14/90	2.45	32.7	329616				329616
2/21/90	2.52	29.4	317520				317520
3/1/90	2.37	33.2	334656				334656
3/7/90	2.41	32	299520				299520
3/14/90	2.44	30.6	308448				308448
3/21/90	2.09	29.3	295344				295344
3/28/90	2.53	31.7	319536				319536
4/4/90	2.52	32.3	325584				325584

4/11/90	2.32	29.7	299376				299376
4/18/90	2.12	31.4	633024				633024
5/9/90	2.45	29.5	913320				913320
5/31/90	2.62	30.2	782784				782784
6/14/90	2.5	40.0	1324800	30.63			1411200
7/19/90	2.60	38.0					1723680
8/16/90	2.33	34.0					1640160
9/24/90	2.63	30.1					1798776
11/7/90	2.63	26.1					1052352
11/19/90	2.72	25.2					508032
12/5/90	2.73	22.9	247320				379224
12/12/90	2.70	22.4	354816				354816
12/27/90	2.82	19.7	382968				382968
1/8/91	2.70	19.3	361296				361296
1/22/91	2.73	19.4	321264				321264
1/31/91	2.71	18.4	198720				198720
2/6/91	-	18.0	349920				349920
2/27/91	2.75	15.0	313200				313200
3/7/91	2.74	19.0	205200				205200
3/14/91	2.79	25.0	252000				252000
3/21/91	2.78	23.0	331200				331200
4/3/91	2.61	26.5	686880				686880
4/26/91	2.39	46.0	1391040				1391040
5/15/91		43.0	1671840				1671840
6/19/91	2.56	36.0	1477440	27.99			1814400
7/24/91	2.62	32.1					1456056
8/21/91	2.54	27.6					1112832
9/18/91	—	24.3					1102248
10/23/91	2.55	22.8					804384
11/6/91	2.60	19.2					483840
11/27/91	2.71	18.3					461160
12/11/91	2.80	16.9	328536				255528
12/18/91	2.73	16.9	182520				182520
12/26/91	2.74	16.1	173880				173880
1/2/92	2.73	15.0	140400				140400
1/8/92	2.76	14.8	138528				138528
1/15/92	2.75	17.2	185760				185760
1/23/92	2.79	17.0	171360				171360
1/29/92	2.77	17.1	160056				160056
2/5/92	2.70	18.7	201960				201960
2/13/92	2.76	22.2	223776				223776
2/19/92	2.82	34.3	321048				321048
2/26/92	2.45	40.0	403200				403200
3/4/92	2.38	51.0	514080				514080
3/11/92	2.35	51.0	514080				514080
3/18/92	2.49	66.0	665280		665280		665280
3/25/92	2.34	80.9	815472		815472		815472
4/1/92	—	86.5	1370160		1370160		1370160
4/16/92	2.45	84.7	1280664		1280664		1280664
4/22/92	2.42	81.0	758160		758160		758160
4/29/92	2.47	75.0	1134000		1134000		1134000
5/13/92	2.45	77.0	2716560		2716560	108.39	2716560
6/17/92	2.55	62.0	2723040	49.54			2723040
	Overall Winter Average (gpm):			70.68			
	Overall Annual Average (gpm):						59.82
	Overall Peak Flow Average (gpm):					139.42	
	Low Design Flow = 15 gpm						

ATTACHMENT H

MATERIALS OF CONSTRUCTION

PREPARED BY: Rod Jackson/Sacramento

DATE: October 26, 1992

SUBJECT: Materials of Construction
Treatment Plant for the Boulder Creek Operable Unit
Iron Mountain Mine

PROJECT: RDD69017.TP.04

Introduction

This memorandum discusses materials of construction for facilities to pump and treat acid mine drainage (AMD) from Iron Mountain Mine. It also addresses basic requirements for construction materials for facilities that shall be incorporated in the design and construction of the treatment plant.

Information in this memorandum emphasizes prevention of materials degradation by corrosion, chemical reactions, and weathering. The information represents minimum requirements for the design and construction of facilities. It is intended to be used with other performance standards established in Technical Memorandum TP.03.

The basis for the recommendations herein include consideration of the characteristics of AMD from the Richmond portal, Lawson portal, and Old/No. 8 Mine seep; lime; and resultant process sludge. Field and laboratory studies were used to supplement (available) information in literature.

The minimum design life of permanent facilities is considered to be 30 years. All equipment shall be selected for a 15-year service life.

Summary and Recommendations

AMD from Iron Mountain Mine can be generally characterized as a sulfuric acid solution with a concentration of 1 to 7 percent by weight, as shown by historical data. The AMD also contains iron and smaller concentrations of other ions. For construction materials design purposes, AMD should be considered to consist of a 10 percent solution of sulfuric acid containing 1 percent iron at a temperature of 50 to 130°F.

Sulfuric acid is a common industrial acid, and considerable information on construction materials that are suitable for handling it exists in available literature.

Because the AMD is largely a sulfuric acid solution, the literature provides a basis for identification of materials that are candidates for the proposed collection and treatment system. A summary of suitable and unsuitable materials for handling the AMD is presented in Table TP.04-1.

Type 316 stainless steel is considered to be the best practical material for metallic components in AMD service. It has adequate, but not excessive, resistance to the range of AMD characteristics that are expected to occur, and it is widely available in numerous forms. High density polyethylene is considered to be the best practical pipe material because it is chemically resistant to AMD, and it is widely available and proven in mountain environments.

An important difference between Iron Mountain Mine AMD and industrial sulfuric acid is the iron and other metals in AMD. The ferrous and ferric ions impart a strongly oxidizing characteristic to sulfuric acid. Other metals in AMD, including copper, zinc, aluminum, and magnesium, can act as inhibitors that reduce corrosion rates to below those expected for metals in pure solutions of sulfuric acid. In combination with aeration, the oxidizing characteristics of the iron in AMD and the effects of other metal ions make the corrosion of metals in AMD somewhat different than in pure sulfuric acid. In formulating the material recommendations in Table TP.04-1, we have attempted to take into account the effects of metal ions in AMD.

Prior to implementation, it is recommended that a short-term corrosion test of metals be conducted to confirm that identified metals are indeed resistant to AMD. The test is recommended only for certain metals, including high-silicon cast iron, Alloy 20, Type 316 stainless steel, and lead. This test would consist of a limited number of coupons placed in the AMD discharge from the Lawson portal, Richmond portal, and Old/No. 8 Mine seep for a period of 30 days.

Construction materials for lime-handling components at the treatment plant include most of the materials that are recommended for AMD. In addition, virtually all of the materials that are unsuitable for AMD are suitable for handling neutralized AMD and lime sludge, except for bare steel and cast iron, lead, aluminum, zinc, glass, polysulfides, and oil-base enamel paints. Concrete structures should be made with Type V cement for sulfate resistance.

Table TP.04-1
Construction Materials Summary
Iron Mountain Mine AMD Before Neutralization

Suitable	Unsuitable
Metals	
Hi-Silicon Cast Iron (Duriron, Durichlor 51) Alloy 20 Chlorimet 2/Hastelloy B Chlorimet 3/Hastelloy C Gold Tantalum Zirconium Type 316[a] and Type 317 Stainless Steel CD4M (Durcomet 100) Stainless Steel Lead[b]	Carbon Steel Cast Gray & Ductile Iron Aluminum Titanium All 300 Series Stainless Steels (except Types 316 and 317) All 400 Series Stainless Steels 17-4 pH Stainless Steels Nickel Nickel-Copper Alloys (Monel) Copper & Copper Alloys Inconel
Plastics[c]	
High-Density Polyethylene (HDPE) PVC & CPVC Fluoropolymers Chemical-Resistant Epoxies Polypropylene Polybutylene Phenolics	Nylon Acetal
Elastomers	
Hypalon Viton Natural Rubber Ethylene Propylene and EPDM PTFE (Teflon)[d]	Polysulfide Polyurethane Silicone Rubber Buna-S
Linings/Coatings	
Polyester Vinyl Ester Amine Epoxy Phenolic	Polyamide Epoxy Coal Tar Epoxy Oil-Base Enamels
Other	
Graphite Polyester Mortar Furan Mortar Glass	Portland Cement Concrete[f] Wood

[a]Up to 10 percent H_2SO_4 at 120°F, and only if aerated.
[b]Subject to erosion in high velocity flow; considered marginal for long-term service.
[c]Outdoor use requires painting, shading, or otherwise providing resistance to sunlight, except carbon-filled HDPE.
[d]Chemically resistant, but creeps under stress.
[e]Available in thin films for light duty and fiberglass-mat reinforced for heavy duty.
[f]Lining or coating required where exposed to fumes, immersion, or spillage.

Tests of soil conditions at the site indicate that they range considerably in corrosiveness. However, the use of buried components is expected to be minimal for this project. No special protective measures are required for components that are in contact with the soil unless the site is subject to AMD fumes, spillage, or subject to continuous wet conditions where acid formation could occur. In these situations, the recommendations for AMD materials should be followed.

Discussion

Chemical Characterization

The most corrosive material associated with this project is untreated AMD. The chemical characteristics of AMD from the Richmond portal, Lawson portal, and Old/No. 8 Mine seep, on the basis of historical records, are summarized in Table TP.04-2. The results of tests for pH and temperature made during a recent site visit, conducted on August 11, 1992, are presented in Table TP.04-3.

The data show that the AMD characteristics vary somewhat with the source. Richmond portal produces AMD with the highest concentrations of various chemical species, and Lawson portal and Old/No. 8 Mine seep produce somewhat less concentrated AMD.

For materials considerations, the AMD can be characterized as a sulfuric acid solution containing iron and smaller amounts of other dissolved solids. The concentration of the sulfuric acid ranges from approximately 1 to 7 percent by weight, on the basis of the sulfate concentration and the acidity, from historical records, of AMD. Records also indicate that the temperature of AMD at the sources ranges from 50° to 130°F. Suspended solid concentrations are very low.

Tests were made for pH and electrical resistivity of the lime sludge in the drying beds at the existing ICI Americas treatment plant. The test results are presented in Table TP.04-4. The lime sludge is shown to be moderately alkaline in terms of pH, and has a low electrical resistivity.

Additional information on chemical characteristics and corrosion is provided in Appendix A.

Table TP.04-2
AMD Characteristics
December 1983-December 1984

Characteristic[a]	Richmond Portal		Lawson Portal		Old/No. 8 Mine Seep	
	(Avg)	(Max/Min)	(Avg)	(Max/Min)	(Avg)[c]	(Max/Min)
Flow (gpm)	67	240/17	46	91/27	--	136/40
pH (units)	0.8	1.4/0.6	1.8	2.8/1.5	--	3.1/1.7
Conductivity (umhos/cm)	199,400	250,000/105,000	36,700	59,800/14,300	--	9,800/5,100
Temp (°F)	79	93/57	68	81/64	--	64/57
Acidity (mg/l $CaCO_3$)	54,600	71,500/35,180	12,700	16,800/8,700	--	7,850/5,060
Aluminum	1,185	1,520/602	507	596/409	--	570/412
Arsenic	32.5	48/13	4.8	6.8/3.6	--	0.5/0.03
Cadmium	10.8	14.4/43.5	2.7	3.8/1.8	--	0.7/0.3
Calcium	170	234/105	197	290/122	--	73/138
Chloride	75	277/7	5.2	21/<1.0	--	35/<1.0
Chromium[c]	0.50	0.90/0.02	0.18	0.47/0.04	--	0.18/0.03
Copper	190	362/118	56	65/47	--	136/83
Iron (Total)	13,300	16,200/7,300	4,045	5,790/3,000	--	1,900/857
Iron (Fe+2)	11,400	12,900/7,500	2,931	3,420/2,070	--	406/1,200
Lead	3.6	6.6/1.4	0.40	1.6/0.13	--	0.06/<0.005
Magnesium	599	734/309	371	484/271	--	389/248
Manganese	12.9	16.5/7.1	9.6	13/6.3	--	15/10
Mercury (μg/l)	1.1	4.5/<0.1	<0.1	0.2/<0.1	--	0.3/<0.1
Potassium	168	284/64	45	86/30	--	4/<2
Silica	23.7	50/2.5	15	49/4	--	28/5
Sodium	112	140/58	31	37/22	--	7/5.6
Sulfate	58,500	72,000/37,600	14,039	21,300/6,000	--	8,860/3,720
Thallium	0.19	0.3/0.08	0.03	0.09/<0.01	--	<0.01
Zinc	1,479	2,150/695	383	521/284	--	70/33
TDS	71,000	91,900/43,410	21,200	27,700/17,000	--	12,550/8,646
TSS	74	300/12	17	122/<1	--	64/<1

[a]All values are in mg/l unless otherwise noted.
[b]Averages not calculated for this memorandum.
[c]Value given is for chromium in the +6 valence state.

Table TP.04-3 AMD Characteristics August 11, 1992		
Source	**pH, Units**	**Temperature, °C**
Richmond Portal	0.33	34.4
Lawson Portal	1.40	20.3
Richmond & Lawson Portals Combined	0.42	34.2
Old/No. 8 Mine Seep	2.98	20.8

Table TP.04-4 Lime Sludge Characteristics August 11, 1992		
Source	**pH, Units**	**Average Bulk Electrical Resistivity, ohm-cm[a]**
ICI Americas Treatment Plant Sludge Bed	8.5 (dry surface) 10.0 (moist sludge)	420 to 510
[a]For measurement method, see discussion of soil resistivity tests.		

Materials for Handling Sulfuric Acid

There is a large amount of information in the literature on materials used for handling and storage of sulfuric acid solutions. However, most of this information addresses industrial purity sulfuric acid and does not adequately consider other ions present in the AMD. Still, the literature does provide some perspective on the spectrum of materials for these applications. Fontana and Green (1978) summarize the applications as follows:

Steel

Ordinary carbon steel is widely used for storing sulfuric acid in concentrations over 70 percent. More dilute solutions attack steel very rapidly, and the effect on ordinary cast iron is similar.

Lead

Lead has a very low corrosion rate in dilute sulfuric acid at ambient temperatures because of the formation of an insoluble, protective layer of lead sulphate. Chemical lead (ASTM B29) is the most widely used form of lead in sulfuric acid service. However, lead and its protective film of lead sulfate are soft and are readily abraded.

ever, lead and its protective film of lead sulfate are soft and are readily abraded. High-velocity flow and suspended solids can cause erosion-corrosion, which may produce exceptionally high corrosion rates. For this reason, lead is rarely used for pumps and valves, and is most commonly used as a lining for storage vessels.

High-Silicon Cast Iron

This cast iron alloy, most commonly known as Duriron, contains approximately 14 percent silicon and is widely used for sulfuric acid solutions. It is a relatively low-cost material when compared with its acid-resistant properties, and it contains no strategically important elements. Durichlor 51 is a similar alloy that contains chromium in addition to silicon for better chloride resistance. Duriron and Durichlor 51 are hard, brittle metals. They are susceptible to severe thermal shock and are available only in cast form. These materials are typically used for pump castings, valve bodies, pipe, and fittings.

Alloy 20

This alloy is best known as Carpenter 20 in wrought form and Durimet 20 in cast form. It comprises 29 percent chromium and 20 percent nickel, with lesser amounts of copper and molybdenum, in an iron base. This alloy is very resistant to sulfuric acid and is used for pumps and valves in acid production plants.

Nickel-Molybdenum-Chromium Alloys

The best known nickel-molybdenum alloys for sulfuric acid consist of approximately 2/3-nickel and 1/3-molybdenum. Commercial alloys are Chlorimet 2 and Hastelloy B. These alloys are expensive because, in addition to their alloy content, they usually require heat treatment for corrosion resistance.

Chlorimet 3 and Hastelloy C contain approximately 18 percent each of chromium and molybdenum in a nickel base. They resist most any exposure conditions involving sulfuric acid.

Conventional Stainless Steels

Type 316 is practically the only conventional wrought stainless steel that is used for sulfuric acid solutions, and its resistance is limited to low concentrations and temperatures. Maintenance of a passive surface film and subsequent corrosion resistance is dependent upon good aeration and absence of chemical reducing agents in the sulfuric acid handled. The chemical composition of the alloy is 18 percent chromium, 8 percent nickel, and 3 percent molybdenum in an iron base. Its cast equivalent is CF-8M.

Other Alloys and Metals

Copper and copper alloys, aluminum, titanium, and zinc are not widely used for sulfuric acid solutions. Noble and rare metals such as gold, platinum, tantalum, and zirconium are highly resistant to sulfuric acid and are used for components (such as controls) where little or no corrosion can be tolerated.

Plastics

Virtually all thermosetting and thermoplastic materials are resistant to dilute sulfuric acid, except for acetal and nylon. However, elevated temperatures can cause rapid reductions in mechanical properties. In addition, exposure of plastics to sunlight can result in deterioration from exposure to ultraviolet light, so painting, covering or shading these materials is appropriate. The exception to these limitations is high-density polyethylene, which is typically filled with about 1.5 percent carbon black (an effective UV inhibitor) and may be used without other protection.

Elastomers

Many elastomers are commonly used for components such as gaskets and hoses and they are resistant to 10 percent sulfuric acid. These materials include Hypalon, Viton, EPDM, natural rubber and Teflon. Polysulfides, polyurethane, Buna-S, and silicone rubbers are not resistant to 10 percent sulfuric acid.

Coatings

Polyester, vinyl ester, and some amine and novolac epoxies are the only coatings resistant to sulfuric acid.

Inorganic, Nonmetallic Materials

Acceptable materials for sulfuric acid handling include glass, graphite, and mortars made with polyester and furan resins. Portland cement in any form is not compatible with sulfuric acid.

Wood

Wood is not suitable for sulfuric acid solutions because of charring caused by dehydration of the cellulose in wood by sulfuric acid. (Refer to Appendix A for more information.)

Components used for the treatment facilities may come from various manufacturers and may consist of a number of materials. Therefore, additional information is provided to cover a range of materials in addition to those previously discussed. Materials charts for 10 percent sulfuric acid from a well-known manufacturer are presented in Appendix B. Crorrosion resistance tables may be found in Schweitzer

(1991). However, these materials charts are for industrial purity sulfuric acid and **not specifically for AMD**. Any discussion of specific materials in this text supersedes the respective information in Appendix B.

Materials for Lime Handling

Lime consists of calcium oxide (quick lime) or calcium hydroxide (slaked lime). When dry, these materials are considered virtually noncorrosive (National Lime Association, 1976). When wet, however, lime materials are corrosive to certain materials because of their high alkalinity (indicated by pH 11 to 13). The corrosivity of wet lime is still considerably less than that of AMD.

Metals that are corroded by hydrated lime include aluminum, zinc (galvanizing), tin, and lead. These metals are affected because their corrosion products are dissolved by alkaline and acidic solutions, and fresh surfaces are continuously exposed to corrosive action.

Nonmetallic materials that are adversely affected by the high alkalinity of slaked lime include glass, silicate cements, vinyl coatings, and polysulfide-based elastomers.

Bench Tests Using AMD

Measurements of the electrical potential of common construction metals in AMD were made using AMD samples collected from Iron Mountain Mine. The purpose of the tests was to assess the galvanic relationships between metals (for further information, refer to Appendix A) and to determine the tendency for development of protective surface films.

The test results are shown in Table TP.04-5. Metals are listed in order of electrical potential with respect to a common reference electrode. Metals with the most negative potential are the most actively corroding (magnesium, zinc, and galvanized steel). Those with the lowest negative potential, or a positive potential, have a lower tendency for corrosion under the test conditions (Type 316 stainless steel, graphite, and Durichlor 51).

The electrical potential for steel indicated that it was actively corroding in the test. The potential for lead was less negative than normal because of the formation of protective lead sulfate. Although the potentials for brass and copper were low, they were observed to be etched while immersed in AMD and were considered to be corroding.

Table TP.04-5 Galvanic Series of Metals in AMD[a]	
Metal	**Electric Potential[b]**
Magnesium (most active)	-1.30
Zinc	-1.03
Galvanized Steel	-1.00
Low-carbon Steel	-0.55
Lead	-0.22
Copper	-0.09
Brass	-0.08
Type 316 Stainless Steel	+0.24
Graphite	+0.26
Durichlor 51 (least active)	+0.27

[a]AMD from Richmond and Lawson portals combined flow, August 11, 1992.
[b]Copper Sulfate Reference Electrode, room temperature.

The potential for Type 316 stainless steel in AMD is of particular interest. Stainless steel alloys rely upon a protective film on the surface for corrosion resistance. The film is formed upon exposure to certain conditions in the environment. If the film does not form, the potential is quite negative (similar to ordinary steel), and corrosion resistance is poor. If the potential of stainless steel has a very low negative value or is positive, it is taken as evidence that the protective film has formed. Therefore, the positive potential of Type 316 stainless steel in AMD indicates that the alloy is at least moderately resistant to corrosion by AMD.

Additional information on AMD properties was obtained from previous studies performed by CH2M HILL (Smith, 1991). Tests showed that the redox potential, or E, of AMD was +450 to +550 millivolts. This indicates an oxidizing characteristic and suggests an absence of reducing agents, which could adversely effect the corrosion resistance of Type 316 stainless steel in AMD.

Site Observations

Observations of existing materials used in conjunction with AMD collection at the site are as follows:

- HDPE piping is used for collection of AMD and transmission to existing treatment plant. The pipeline has stainless steel air relief valves and CF-8M stainless steel valves. Other miscellaneous fittings are stainless steel of an unidentified alloy. No visible deterioration was observed.

- Stainless steel flumes are used for collection and transmission of AMD from the Lawson and Richmond portals to the Boulder Cementation Plant. Casual inspection of the flume showed evidence of thinning due to corrosion on surfaces immersed in AMD. The age of the flume and the identity of the stainless steel alloy were not determined.

- PVC pipe is used at miscellaneous locations for various components with no evidence of deterioration. The age of the pipe is unknown.

- Rubber sheeting is used for lining of the collection sump for Richmond portal AMD. The lining appeared to be in good condition, except for some evidence of degradation where the lining was completely exposed to sunlight.

- Numerous concrete structures in use have corrosion damage where AMD is in contact with the concrete.

- Numerous steel pipes and galvanized steel culvert pipes are in use or are abandoned at the site, and all showed evidence of acid corrosion in the form of holes or disintegration of the pipe.

Soil Resistivity Test Results

To assess the potential for corrosion of underground components in the treatment system, the electrical resistivity of the earth was measured at several locations in the project area. Tests were made in accordance with ASTM G57 using the 4-pin method. This test provides an indication of corrosivity of the soil or other earthen materials at a specific site. Lower resistivity values indicate that corrosion is more likely to occur. Resistivities less than about 3,000 ohm-centimeters (ohm-cm) indicate corrosive soils, and values less than 1,000 ohm-cm indicate particularly corrosive conditions.

The test results are presented in Table TP.04-6. They indicate that resistivities well below 1,000 ohm-cm were found at Minnesota Flats, at the entrance to Brick Flat Pit, and at the sludge drying beds of the existing ICI Americas Treatment Plant. The resistivity values at the proposed treatment plant site at Brick Flat Pit were 100,000 to 567,000 ohm-cm. These resistivity values are very high and are attributed to the rock at the site and the dry conditions at the time of test. The remaining sites had moderate resistivity values.

Samples of surface soils were taken from selected sites and tested for pH and resistivity using a soil box in the laboratory. The results are shown in Table TP.04-7. The resistivity test results indicate basic agreement with the results using the 4-pin method.

Table TP.04-6
Soil Resistivity Test Results

Location	Depth/Feet	Resistivity/ ohm-cm
Minnesota Flats	0-2.5	500
	2.5-5.0	320
	5.0-7.5	230
	7.5-20	260
	10-15	300
Old/No. 8 Mine Seep, below road	0-2.5	22,500
	2.5-5.0	4,940
	5.0-7.5	8,570
	7.5-20	4,810
	10-15	2,070
ICI Americas Treatment Plant	0-2.5	4,900
	2.5-5.0	7,100
	5.0-7.5	3,330
	7.5-20	5,310
	10-15	2,400
ICI Americas Treatment Plant (sludge drying bed)	0-2.5	850
	2.5-5.0	330
	5.0-7.5	320
	7.5-20	470
	10-15	890
Wide, flat area outside entrance to Brick Flat Pit	0-2.5	500
	2.5-5.0	500
	5.0-7.5	170
	7.5-20	300
	10-15	260
Brick Flat Pit—proposed treatment plant site	0-2.5	280,000
	2.5-5.0	323,000
	5.0-7.5	300,000
	7.5-20	100,000
	10-15	

Table TP.04-7 Soil Sample Test Results			
	Resistivity/ohm-cm		
Location	As-Received	Saturated	pH
Wide flat area outside entrance to Brick Flat Pit	31,000	630	5.0
Minnesota Flats	40,000	1,200	5.5
Brick Flat Pit—proposed treatment plant site	2,400,000	67,000	5.5

References

Fontana, M.G., and N. D. Greene. 1978. *Corrosion Engineering*. 2nd ed. McGraw-Hill Book Company.

National Lime Association. 1976. *Lime Handling Application and Storage in Treatment Processes.* Bulletin 213, 2nd ed. Washington, D.C.

Schweitzer, F. 1991. *Corrosion Resistance Tables: Metals, Nonmetals, Coatings, Mortars, Plastics, Elastomers, and Linings and Fabrics.* 3rd ed. New York: Marcel Dekker, Inc.

Smith, D. 1991. *Summary of Iron Mountain Mine and Experiment Memorandum.* Redding, California: CH2M HILL.

Appendix A
Supplemental Information

Appendix A
Supplemental Information

Further discussion of the significance of the chemical characteristics of AMD relative to materials is presented below.

pH and Acidity

The pH value is the negative logarithm of the concentration of ionized hydrogen (or hydronium) ions in water or soil. Thus, a pH change of 1.0 unit represents a 10-fold change in hydrogen ion concentration. The most commonly discussed pH range is pH 1 to 14. However, it is possible to have pH zero when the hydrogen ion concentration is 1 gram per liter, and negative pH values when ion concentrations are higher.

In pure solutions, such as hydrogen chloride in deionized water, the pH provides a good measure of acid intensity because all of the hydrogen added is essentially ionized.

In more complex solutions, such as sulfuric acid solutions and solutions with near-neutral pH, only a portion of the hydrogen is ionized, and only this portion is shown by a pH reading. As described above, the acidity provides a quantitative measure of the total ionized and ionizable hydrogen. The acidity or acid strength is a better measure of the corrosiveness of the substance in sulfuric acid and near-neutral pH solutions.

Sulfuric Acid

Sulfuric acid is one of the most common acids used in industry. Sulfuric acid has the chemical formula H_2SO_4. In water, the acid ionizes in two stages:

H_2SO_4	--> $H^+ + HSO_4^-$	(primary ionization)
HSO_4^-	--> $H^+ + SO_4^{-2}$	(secondary ionization)

In dilute solution, sulfuric acid undergoes almost complete primary ionization. The secondary ionization is less complete.

Sulfuric acid has a strong affinity for water. Dilution of concentrated sulfuric acid produces a large amount of heat as hydrogen ions are formed and water molecules become attached to sulfuric acid molecules (hydration). So great is the affinity of strong acid for water that the acid will remove hydrogen and oxygen, in addition to water, from many compounds containing these elements. For example, organic substances containing hydrogen and oxygen in the proportion of 2 to 1, such as cellulose, $(C_6H_{10}O_5)_x$, in wood and paper, are charred by exposure to sulfuric acid.

Aqueous solutions of sulfuric acid are strong acids and act as an oxidizing agents, particularly when hot and concentrated.

Metallic Corrosion

Metallic corrosion usually occurs as a result of corrosion cells on the surface. The reaction is usually electrochemical because it involves chemical changes with a simultaneous flow of electrons between an anode or anodic area and a cathode or cathodic area.

At pH values from about 4 to about 10, oxygen is a key determinant of the corrosion rate because it is a rate-limiting ingredient in the chemical reactions at the cathode. Below about pH 4, hydrogen ions are reduced at the cathode, and because they are present in abundance, the corrosion reaction proceeds much more quickly than at higher pH values. This is called acid corrosion.

Galvanic Series

Metals can be ranked in order of their electromotive force (EMF) compared to a common reference electrode. An activity ranking of this type is referred to as a galvanic series and is usually given for seawater as a standard, although the galvanic relationships vary among different solutions.

The galvanic series allows prediction of which metals will corrode when multiple metals are connected together and placed in an electrolyte. Metals higher on the list will corrode before metals lower on the list. Also, metal ions in solution composed of materials lower on the galvanic series tend to accelerate corrosion of metals higher on the list.

Metals and alloys that develop passive films on their surfaces have variable positions in a galvanic series, depending upon whether the protective film is present. These materials usually corrode at much higher rates if environmental conditions are not conducive to formation of protective films.

Electrical Conductivity

Because corrosion reactions involve the flow of electrons through the environment, the electrical conductivity of the soil or fluid is a factor that determines the corrosion rate. Electrons flow more readily in a conductive environment, and therefore corrosion rates are higher compared to less conductive environments. Dissolved solids contribute to conductivity in fluids.

In solids such as soil, factors that contribute to conductivity include moisture content, particle size, and mineralization. The electrical conductance of soil is usually measured as its reciprocal, resistivity. High conductivity corresponds to low resistivity, and indicates an increased tendency for corrosion.

Forms of Corrosion

Corrosion of metals is manifested by pitting and thinning of the metal surface. The rate of metal loss is given by weight loss over a period of time, or, more commonly, by loss of thickness. The loss of thickness due to corrosion is usually given in mils per year (mpy) where 1 mil equals 0.001 inch.

The corrosion rate that is acceptable in a given situation depends upon the thickness and operational tolerances of the component considered. However, general corrosion rates for long service life should be less than 20 mpy. For critical components such as valves and controls, corrosion rates should be no more than 3 to 5 mpy.

Chemical attack on nonmetallic materials, such as plastics, is usually shown by degradation of mechanical properties. This is usually the result of chemical reaction between the chemical and one or more of the functional groups in the molecules of the plastic. Degradation is usually more rapid at higher temperatures because of the increased reaction rate and softening of the plastic.

Corrosive attack on concrete almost always results from the reaction of an acid with the alkaline cement paste. The reaction neutralizes the paste, causing it to lose its bonding qualities. Etching, loss of aggregate, and spalling result from chemical attack by acids, and especially strong acids like sulfuric acid.

Appendix B
Corrosion Resistance Charts

Guide to the Selection of Durco Corrosion Resisting Non-Metallics

The Duriron Company, Inc., has been a producer of non-metallic equipment for the handling of corrosive chemicals for over twenty years beginning with the introduction of a cast epoxy formulation, DURCON®6. The Durco plastic line has expanded over the years to include Durco PTFE, Durco PFA, and Durcothene (Very High Molecular Weight Polyethylene) lined equipment as well as structural composite materials; DURCON 730 and vinyl ester.

The Duriron Company Inc., produces all non-metallic equipment in-house and maintains an active research and development laboratory for non-metallics which complements the Company's well known alloy development program.

The corrosion chart in this bulletin is intended to be a guide for the selection of the proper corrosion resistant plastic for a given application. The ratings may be used as a guide for material selection but should not be considered a guarantee or blanket recommendation. The ratings are the compilation of extensive laboratory tests, field tests, operating experience, and best judgment. Many factors must be considered when selecting a non-metallic material for a corrosive service. These include: concentration of chemicals present; harmful contaminants; velocity; solids in suspension; type of design of equipment; continuous or intermittent operation; maximum, minimum, and normal operating temperature; and any other peculiarities characteristic of the solution.

DURCO NON-METALLICS

Durco Designation	Durco Symbol	Description	Max. Service Temperature
DURCON 6	DU6	Silica filled epoxy	215° F (102° C)
Durco PTFE	PTFE	Tetrafluoroethylene polymer	400° F* (204° C)
Durco PFA	PFA	Perfluoroalkoxy polymer	400° F (204° C)
Durcothene	UMPE	Very high molecular weight polyethylene	200° F (93° C)
*Most Durco equipment totally lined with PTFE is limited to 300° F (149° C).			
Durcon 730	D730	Glass fiber reinforced epoxy	300° F (149° C)
Durco vinyl ester	VE	Vinyl ester laminate	225° F (107° C)

MECHANICAL AND PHYSICAL PROPERTIES AT 73° F

Durco Designation	Specific Gravity	Flexural Strength		Flexural Modulus		Tensile Strength		Ultimate Elongation %	Coefficient of Linear Thermal Expansion cm/cm/°C × 10^{-5}
		psi	MPa	psi x 10^5	MPa x 10^2	psi	MPa		
DURCON 6	1.98	20,000	138	20.0	138	13,000	90	—	3.6 (23-177° C)
Durco PTFE	2.18	—	—	0.70	4.8	4,000	28	300	12.6 (21-60° C)
Durco PFA	2.15	—	—	1.00	6.9	4,000	28	300	12.06 (21-100° C)
Durcothene	0.94	—	—	1.00	6.9	5,000	34	350	18-21.6 (-18-100° C)
Durcon 730	1.90	24,000	165	22.0	152				
Durco vinyl ester	1.35	23,000	159	8.50	58.6				

	Durcon 6	PTFE—PFA	Durcothene	Durcon 730	VE Laminate
Acetate solvents	E	E	G	E	P
Acetic acid, all strengths	G	E	G	G	S
Acetic anhydride	G	E	G	G	P
Alum (slurry)	G	S	E	G	E
Aluminum chloride	E	E	E	E	E
Aluminum sulfate & H_2SO_4	G	E	E	S	S
Ammonium chloride	E	E	E	E	E

	Durcon 6	PTFE—PFA	Durcothene	Durcon 730	VE Laminate
Ammonium fluoride	P	E	E	P	S
Ammonium hydroxide	S	E	E	G	S
Ammonium nitrate	E	E	E	G	E
Ammonium phosphate	E	E	E	G	G
Ammonium sulfate	E	E	E	E	E
Ammonium sulfate & H_2SO_4	G	E	G	S	S
Aniline dyes	S	E	G	G	P

	Durcon 6	Durcon 70	PTFE—PF	Durcothen	Durcon 73	VE laminat
Aniline hydrochloride	G	—	E	—	—	S
Anodizing solutions	G	S	E	S	S	S
Antimony trichloride	E	E	E	E	E	G
Arsenic acid	G	G	E	E	G	S
Barium chloride	E	E	E	E	E	E
Barium nitrate	E	G	E	E	G	—
Barium sulfate	E	E	E	E	—	E
Benzoic acid	G	G	E	—	G	G
Black liquor (slurry)	G	G	P	E	G	S
Boric acid	G	G	E	E	G	G
Brine, acid	E	E	E	E	E	E
Brine, alkaline	S	G	E	E	G	S
Bromine, dry	G	P	E	S	P	P
Bromine, wet	S	P	E	S	P	P
Cadmium sulfate	E	E	E	E	E	E
Calcium bisulfate	E	E	E	E	E	E
Calcium bisulfite & H_2SO_4	G	S	E	E	S	S
Calcium chloride	E	E	E	E	E	E
Calcium hydroxide (lime)	S	G	G	E	G	—
Calcium hypochlorite	S	P	E	G	P	E
Calcium phosphate	E	G	E	E	E	E
Carbon disulfide	E	E	E	E	E	P
Carbonic acid	E	E	E	E	E	S
Carbon tetrachloride	E	E	E	E	E	S
Cellulose acetate	E	E	E	E	E	—
Chloroacetic acid	G	P	E	S	P	P
Chlorinated water	S	P	E	S	P	G
Chlorine dioxide	G	P	E	S	P	G
Chlorine gas, wet	S	P	E	S	P	G
Chromic acid	S	S	E	G	S	S
Citric acid	G	G	E	E	E	G
Copper nitrate	E	G	E	E	G	G
Copper silver nitrate	G	G	E	E	G	G
Copper sulfate	E	E	E	E	E	E
Copper sulfate + 10% H_2SO_4	G	P	E	E	P	G
Cupric chloride	E	E	E	E	E	E
Cuprous chloride	E	E	E	E	E	E
Ethylene dichloride	E	S	E	P	G	P
Fatty acids	E	G	E	E	E	E
Ferric chloride	E	E	E	E	E	G
Ferric ferro-cyanide	E	E	E	E	E	E
Ferric nitrate	G	G	E	E	G	G
Ferric sulfate	E	E	E	E	E	E
Ferric sulfate + 10% H_2SO_4	E	P	E	E	P	G
Ferrous sulfate	E	E	E	E	E	E
Ferrous sulfate + 10% H_2SO_4	E	P	E	E	P	G
Formaldehyde	E	S	E	E	G	S
Formic acid	G	G	E	E	G	G
Glycerin, crude	G	S	E	—	E	G
HCL waste pickle liquor	E	E	G	E	E	G
Hydrochloric acid < 150°F (66°C)	E	E	E	E	E	E
Hydrochloric acid > 150°F (66°C)	E	E	E	E	E	G
Hydrofluoric acid	P	P	E	E	P	S
Hydrofluosilicic acid	P	P	E	E	P	S
Hydrogen peroxide	G	S	E	S	S	S
Hypochlorite bleach	S	P	E	G	P	E
Iodine, dry	G	P	E	—	P	P
Lactic acid	G	G	E	E	G	E
Lead acetate	E	E	E	E	E	E
Lead nitrate	G	G	E	E	G	—
Lead sulfide	E	E	E	E	E	E
Lithophone	G	G	E	E	E	—
Magnesium chloride	E	E	E	E	E	E
Magnesium sulfate	E	E	E	E	E	E
Maleic acid	G	G	E	E	G	G
Malic acid	G	G	E	E	G	E
Manganese chloride	E	E	E	E	E	E

	Durcon 6	Durcon 70	PTFE—PF	Durcothen	Durcon 73	VE laminat
Mercuric chloride	E	E	E	E	E	E
Mercuric nitrate	G	G	E	E	G	G
Mercuric sulfate	E	E	E	E	E	E
Mercurous sulfate	E	E	E	E	E	E
Metal plating solutions	G	G	E	E	G	S
Mine water	E	E	E	E	E	E
Mixed acid	S	P	E	S	P	P
Nickel chloride	E	E	E	E	E	E
Nickel ammonium sulfate	E	E	E	E	E	E
Nitric acid, all strengths	G	S	E	S	S	S
Nitric acid + 3% - 5% HF	P	P	E	G	P	P
Nitrobenzene	S	—	E	P	S	P
Oleic acid	G	G	E	G	G	G
Oleum	P	P	E	P	P	P
Oxalic acid	G	G	E	G	G	G
Phenol	E	P	E	P	P	P
Phosphoric acid + 2% H_2SO_4, 1% HF	S	P	E	E	P	S
Phosphoric acid, all strengths	G	S	E	E	S	G
Picric acid	G	G	E	E	G	G
Phthalic acid	G	G	E	E	G	E
Potassium bisulfate	E	E	E	E	E	E
Potassium chloride	E	E	E	E	E	E
Potassium hydroxide	S	G	E	E	G	S
Potassium iodide	G	G	E	E	G	G
Potassium nitrate	E	G	E	E	G	G
Potassium sulfate	E	E	E	E	E	E
Pyridine sulfate	E	E	E	E	E	—
Sea water	E	E	E	E	E	E
Sodium bicarbonate	E	E	E	E	E	G
Sodium bisulfate	E	E	E	E	E	E
Sodium bisulfite	E	E	E	E	E	E
Sodium chlorate	E	E	E	E	E	E
Sodium chloride	E	E	E	E	E	E
Sodium dichromate	S	S	E	G	S	E
Sodium ferricyanide	G	—	E	E	G	E
Sodium hydroxide	S	G	E	E	G	S
Sodium hydroxide, fused	P	S	E	E	S	S
Sodium hypochlorite	S	P	E	S	P	E
Sodium nitrate	E	G	E	E	G	E
Sodium perchlorate	G	S	E	E	S	—
Sodium phosphate	E	G	E	E	G	G
Sodium sulfate	E	E	E	E	E	E
Sodium sulfide	E	E	E	E	E	E
Sodium sulfite	E	E	E	E	E	E
Sodium thiosulfate	E	E	E	E	E	S
Stannic chloride	E	E	E	E	E	G
Stannous chloride	E	E	E	E	E	E
Stearic acid	G	G	E	G	G	G
Sulfite liquors	G	S	E	E	S	G
Sulfite liquors & H_2SO_4	G	P	E	E	S	S
Sulfur	—	—	E	—	—	—
Sulfur chloride	—	—	E	—	—	—
Sulfur dioxide	G	S	E	E	S	G
Sulfuric acid, sat. with SO_2	S	S	E	G	S	S
Sulfuric acid, up to 100° F(38°C)	G	S	E	G	S	S
Sulfuric acid, 5% to boiling	G	P	E	E	P	G
Sulfuric acid, 60-100%, 176°F (80°C)	S	P	E	P	P	P
Sulfurous acid	G	S	E	E	S	P
Sugar solutions	E	E	E	E	E	E
Tannic acid	E	G	E	E	G	E
Tar and ammonia	S	S	E	E	S	—
Tartaric acid	G	G	E	E	G	E
Titanic sulfate	E	E	E	E	E	E
Toluene	G	G	E	P	G	S
Zinc chloride	E	E	E	E	E	E
Zinc sulfate	E	E	E	E	E	E

E = Excellent — Virtually unattacked under all conditions. G = Good — Generally acceptable with a few limitations. S = Satisfactory — Suitable under some conditions; not recommended for remainder. Consult The Duriron Company, Inc. for details. P = Poor — Unsuitable under all conditions.

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Selecting Durco Corrosion Resisting Alloys

The Duriron Company has devoted more than 75 years to the development of alloys and the production of equipment to provide long, trouble-free life when handling severe corrosives. Pumps, valves, pipe, fittings, anodes, towers and various accessory castings are among the equipment engineered and produced by The Duriron Company in various nickel-base alloys, iron-base alloys, titanium, titanium-palladium, and zirconium alloys.

Long-time association in the field of corrosion and corrosion control has enabled The Duriron Company to keep abreast of the increasing demand for properly designed, corrosion resistant equipment. A well-staffed, corrosion-conscious organization, having the most modern production, quality control and laboratory equipment, assures the ultimate in corrosion resistant alloys.

The corrosion chart in this bulletin is intended to be as a guide to the selection of the proper corrosion resistant material for a given application. The ratings are not a blanket recommendation or warranty, expressed or implied, for any of the materials for any media. These ratings are the compilation of extensive laboratory and field tests, operating experience and best judgement. Many factors must be considered when selecting a material for a corrosive service. These include: primary corrosive; secondary corrosive; contaminants; concentration; pH; maximum, minimum and normal operating temperature; viscosity; velocity; solids in suspension; continuous or intermittent operation; recirculation; degree of aeration; pressure; type or design of equipment; and any other peculiarities characteristic of the solution.

Composition

Durco Designation	Composition							
	Cr	Ni	Mo	Cu	Si	Mn	C	Fe
Ductile Iron					2.75 max		3.0 min	Bal
Carbon Steel	0.50 max	0.05 max	0.20 max	0.30 max	0.60 max	1.00 max	0.30 max	Bal
Durco CF-8M	18.0-21.0	9.0-12.0	2.0-3.0		1.50 max	1.50 max	0.08 max	Bal
Durcomet 100	24.5-26.5	4.75-6.00	1.75-2.25	2.75-3.25	1.00 max	1.00 max	0.04 max	Bal
Durimet 20	19.0-22.0	27.5-30.5	2.0-3.0	3.0-4.0	1.50 max	1.50 max	0.07 max	Bal
Durcomet 5	20.0-22.0	15.0-17.0			4.0-6.0	1.50 max	.025 max	Bal
Durco CY-40	14.0-17.0	Bal			3.00 max	1.50 max	0.40 max	11.00 max
Durco M-35		Bal		26.0-33.0	1.25 max	1.50 max	0.35 max	3.50 max
Nickel		95.0 min		1.25 max	2.00 max	1.50 max	1.00 max	3.00 max
Chlorimet 2	1.00 max	Bal	30.0-33.0		1.00 max	1.00 max	0.07 max	3.0 max
Chlorimet 3	17.0-20.0	Bal	17.0-20.0		1.00 max	1.00 max	0.07 max	3.0 max
Duriron					14.20-14.75	1.50 max	0.70-1.10	Bal
Durichlor 51	3.25-5.00				14.20-14.75	1.50 max	0.75-1.15	Bal
Superchlor	3.25-5.00				14.20-14.75	1.50 max	0.75-1.15	Bal
Durco DC-8		Proprietary Cobalt Base Shaft Sleeve Alloy						
Titanium		N, 0.05 max; H, 0.0100 max; O, 0.35 max					0.10 max	0.30 max
Titanium-Pd		N, 0.05 max; H, 0.0100 max; O, 0.35 max; PD, 0.12 min					0.10 max	0.30 max
Zirconium		N, 0.03 max; H, 0.004 max; O, 0.20 max; Hf, 4.5 max					0.10 max	0.30 max

Specifications and Properties

Durco Designation	Durco Symbol	ACI Designation	Equivalent Wrought Designation	ASTM Specifications*	Mechanical Properties			Typical Brinell Hardness
					Tensile Strength, min, psi	Yield Point min, psi	Elongation min, % in 2"	
Ductile Iron	DCI	None	None	A395	60,000	40,000	18	160
Carbon Steel	DS	None	Carbon Steel	A216, Gr. WCB	70,000	36,000	22	150
Durco CF-8M	D4	CF-8M	316	A744, Gr. CF-8M	70,000	30,000	30	154
Durcomet 100	CD4M	CD-4MC$_u$	Ferralium	A744, Gr. CD-4MC$_u$	100,000	70,000	16	224
Durimet 20	D20	CN-7M	Alloy 20	A744, Gr. CN-7M	62,000	25,000	35	133
Durcomet 5	DV	None	None	None	90,000	40,000	30	175
Durco CY-40	DIN	CY-40	Inconel 600	A494, Gr. CY-40	70,000	28,000	30	147
Durco M-35	DM	M-35-1	Monel 400	A494, Gr. M-35-1	65,000	25,000	25	130
Nickel	DNI	CZ-100	Nickel 200	A494, Gr. CZ-100	50,000	18,000	10	118
Chlorimet 2	DC2	N-7M	Hastelloy B	A494, Gr. N-7M	76,000	40,000	20	230
Chlorimet 3	DC3	CW-6M	Hastelloy C	A494, Gr. CW-6M	72,000	40,000	25	220
Duriron	D	None	None	A518	930#(A)	—	—	520
Durichlor 51	D51	None	None	A518	930#(A)	—	—	520
Superchlor	SD51	None	None	A518	1600#(A)	—	—	520
Durco DC-8	DC8	None	None	None				300
Titanium	Ti	None	Titanium	B367, Gr. C-3	65,000	55,000	15(B)	200
Titanium-Pd	Ti-Pd	None	Titanium-Pd	B367, Gr. C-8A	65,000	55,000	15(B)	200
Zirconium	Zr	None	Zirconium	B752, Gr. 702C	55,000	40,000	12(B)	190

*Whenever an ASTM specification is cited, the Durco alloy will conform to the chemical and mechanical requirements of the latest edition of the specification. (A) Minimum transverse strength. (B) Minimum percent elongation in 1".

Corrosion Resistance
continued

	Ductile Iron & Carbon Steel	Durco CF-8M	Durcomet 100	Durimet 20	Durco CY-40	Durco M-35	Nickel	Chlorimet 2	Chlorimet 3	Duriron	Durichlor 51 & Superchlor	Durco DC-8	Titanium	Titanium-Pd	Zirconium
Phosphoric acid, all strengths	P	G	E	G	S	P	P	E	G	E	E	E	P	P	G
Picric acid	P	G	E	E	G	G	G	E	E	E	E	E	E	E	E
Phthalic acid	S	G	G	G	G	S	S	G	G	E	E	G	G	G	E
Potassium bisulfate	P	G	E	E	S	G	S	G	E	E	E	E	S	S	E
Potassium chloride	S	P	G	G	S	G	S	G	E	G	E	E	E	E	E
Potassium hydroxide	S	S	G	G	E	G	E	E	E	S	S	E	G	G	E
Potassium iodide	S	G	G	G	G	S	S	S	G	G	G	G	G	G	E
Potassium nitrate	S	E	E	E	E	G	E	G	E	E	E	E	E	E	E
Potassium sulfate	S	G	E	E	S	G	S	E	E	E	E	E	E	E	E
Pyridine sulfate	S	G	G	G	S	G	S	E	E	E	E	E	E	E	E
Sea water	S	S	G	G	S	S	S	G	E	G	G	E	E	E	E
Sodium bicarbonate	S	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Sodium bichromate	G	G	G	G	G	G	S	S	G	G	G	E	G	G	E
Sodium bisulfate	P	G	E	E	G	G	S	G	E	E	E	E	G	G	E
Sodium bisulfite	S	G	E	E	P	S	P	S	E	P	P	E	E	E	E
Sodium chlorate	P	G	G	G	G	G	G	P	G	G	E	E	G	G	E
Sodium chloride	S	S	G	G	S	E	G	G	E	G	E	E	E	E	E
Sodium ferricyanide	S	G	G	G	G	G	G	G	E	E	E	E	E	E	E
Sodium hydroxide	S	S	G	G	E	G	E	E	E	S	S	E	G	G	E
Sodium hydroxide, fused	P	P	P	P	E	P	E	S	S	P	P	S	P	P	E
Sodium hypochlorite	P	P	P	P	P	P	P	P	S	G	E	G	E	E	S
Sodium nitrate	S	E	E	E	E	S	G	S	E	E	E	E	E	E	E
Sodium perchlorate	P	S	G	G	P	S	S	G	G	G	E	E	E	E	G
Sodium phosphate	G	G	G	G	G	G	G	G	G	G	G	E	G	G	E
Sodium sulfate	S	G	E	E	G	G	S	E	E	E	E	E	E	E	E
Sodium sulfide	P	G	G	G	E	S	E	G	G	G	G	G	G	G	E
Sodium sulfite	P	G	E	E	S	S	S	S	E	P	P	E	E	E	E
Sodium thiosulfate	P	G	E	E	S	S	S	E	E	E	E	E	E	E	E
Stannic chloride	P	P	P	P	P	P	P	P	S	S	E	E	G	G	P
Stannous chloride	P	P	S	G	S	S	G	G	G	G	G	E	G	G	E
Stearic acid	S	G	E	E	G	S	S	E	E	E	E	E	E	E	E
Sulfite liquors	S	G	G	G	P	P	P	P	E	P	P	G	E	E	E
Sulfite liquors + H_2SO_4	P	P	S	G	P	P	P	S	G	P	P	G	S	S	E
Sulfur	S	G	G	G	G	S	G	G	G	G	G	G	G	G	E
Sulfur chloride	P	P	G	G	G	S	E	E	G	S	E	G	G	G	E
Sulfur dioxide	S	G	E	E	S	S	S	S	E	P	P	E	S	S	E
Sulfuric acid, sat. with SO_2	P	P	P	P	P	P	P	G	G	P	P	G	P	P	E
Sulfuric acid, up to 100°F	P	P	G	G	P	S	P	E	G	E	E	E	P	P	E
Sulfuric acid, 5% to boiling	P	P	G	G	P	G	P	S	G	G	G	G	P	G	E
Sulfuric acid, 60-100% up to 176°F	P	P	P	G	P	P	P	E	G	E	E	G	P	P	P
Sulfurous acid	P	S	S	G	P	P	P	P	E	P	P	G	P	P	E
Sugar solutions	S	E	E	E	E	G	E	E	E	E	E	E	G	E	E
Tannic acid	P	G	G	G	G	G	S	E	E	E	E	E	E	E	E
Tar and ammonia	S	S	G	G	G	P	P	G	G	S	S	G	G	G	E
Tartaric acid	P	G	G	G	G	G	S	G	G	E	E	G	E	E	E
Titanic sulfate	P	G	G	G	P	P	P	G	G	E	E	G	G	G	E
Toluene	S	E	E	E	E	G	E	E	E	E	E	E	E	E	E
Zinc chloride	P	P	S	G	P	G	P	G	E	G	E	E	E	E	E
Zinc sulfate	P	S	E	E	S	G	S	G	E	E	E	E	E	E	E

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ATTACHMENT I

CIVIL SITE AND ACCESS ROAD DESIGN CRITERIA

PREPARED BY: Emily C. Lucero/Redding

DATE: October 26, 1992

SUBJECT: Civil Site and Access Road Design Criteria
Treatment Plant for the Boulder Creek OU
Iron Mountain Mine

PROJECT: RDD69017.TP.05

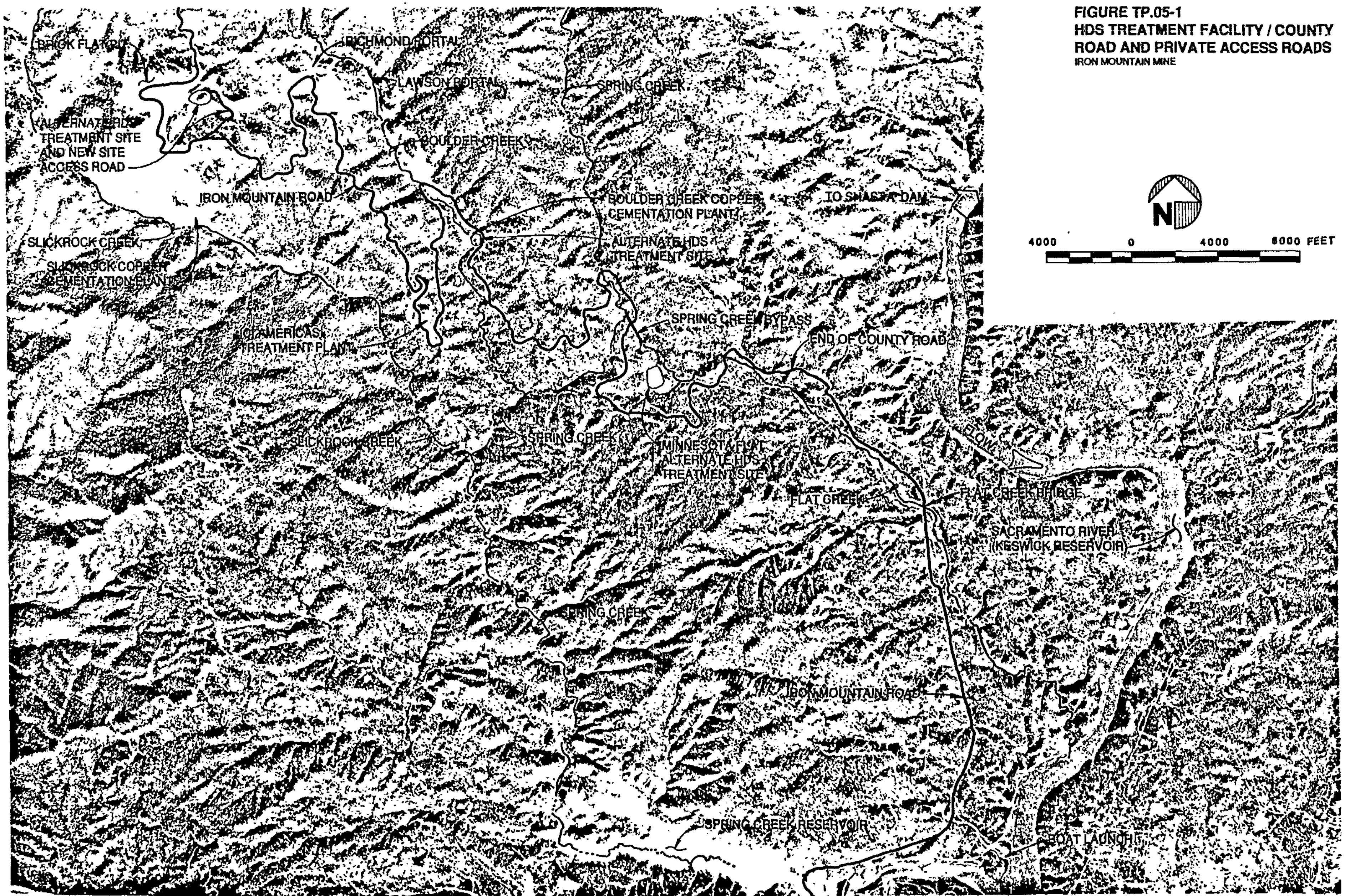
Introduction

This memorandum presents minimum design criteria for the civil engineering aspects of the acid mine drainage (AMD) treatment facility at the Iron Mountain Mine (IMM) project site. The September 30, 1992, Record of Decision by EPA requires the treatment of AMD by the lime/sulfide High Density Sludge (HDS) process. This facility will utilize large quantities of lime which must be hauled to the site, and, depending on site location, may require large quantities of heavy sludge to be trucked from the treatment site to a landfill developed at Brick Flat Pit (BFP).

The minimum civil engineering plant siting requirements and standards for accessibility to the site are independent of the site location and are defined in this memorandum. The design criteria comply with Caltrans Standard Specifications, State of California, Department of Transportation, latest edition; American Association of State Highway and Transportation Officials (AASHTO) policy on Geometric Design of Highways and Streets, latest edition; and, where applicable, the Shasta County Development Standards. Once the plant site location has been determined, the detailed site and roadway design, construction, and maintenance will be the responsibility of the Responsibile Parties.

Iron Mountain Mine is accessible by road from State Route 299, through Iron Mountain Road, a Shasta County owned roadway, then through private roads on the IMM site. Design criteria are presented for improvements to Iron Mountain Road, improvements to the existing IMM main access road, new site access roads, and treatment plant sitework. Refer to Figure TP.05-1 for access road and bridge locations.

FIGURE TP.05-1
HDS TREATMENT FACILITY / COUNTY ROAD AND PRIVATE ACCESS ROADS
IRON MOUNTAIN MINE



RDD69017.TP 05 OCTOBER 1992

Iron Mountain Road

Iron Mountain Road is approximately 7 miles long from State Route 299 to its termination as a county road. In its upper portion, it traditionally carried very light volumes of traffic with no appreciable amount of truck traffic until cleanup projects at IMM began. In this upper portion, there is one bridge over Flat Creek. Approximately 2.6 miles of this road, from the boat ramp (providing boat access to Keswick Reservoir) to the end of the county road, are structurally inadequate for vehicle loads greater than 10 tons and are posted to require permits for loads greater than 10 tons. The paved roadway width decreases, varying from approximately 18 to 20 feet wide.

As part of the final civil engineering design, it is EPA's view that an adequate structural roadway section shall be determined in conjunction with Shasta County based on existing traffic loading plus the anticipated increase in vehicle loading due to the operation of the new treatment facility. Existing design speed, sight and stopping distances, and maximum grades shall be verified for the new roadway loadings. The minimum traffic index shall be 5.0. The design shall also include investigation of the existing section to determine if either an asphalt concrete overlay or removal and replacement is required. Table TP.05-1 lists minimum county road and bridge civil engineering design criteria.

Table TP.05-1
IMM Site/Civil Design Criteria
Shasta County Roads and Bridges[a]

Minimum paved width	20 feet
Minimum graveled shoulder	2 feet (each side)
Minimum graded shoulder	4 feet (each side)
Cross slope, crowned	-3 percent
Maximum ditch foreslope	2:1 (H:V)
Maximum ditch backslope	Not to exceed maximum required for stability
Minimum asphalt concrete thickness[b]	0.14 foot
Minimum aggregate base thickness[b]	0.5 foot
Minimum clear roadway of bridge	24 feet (Traveled way + 2 feet each side)
Design Loading Structural Capacity	HS20 - S16

[a]Based on AASHTO Design Policy, 1990, for local rural roads and Shasta County Development Standards.
[b]Final structural section shall be based on wheel loading and frequency and determined by "R" value testing.

Road improvement plans shall be drawn to scale not less than 1 inch equals 50 feet (1"=50') on standard 24" x 36" sheets and shall be approved by the Shasta County Director of Public Works prior to commencement of construction.

County Bridge

The bridge over Flat Creek is 18 feet wide, one-lane, structurally inadequate for loads greater than 10 tons, and is posted to require a permit for loads over 10 tons. The Shasta County Department of Public Works had budgeted funds to replace the deck of the bridge; however, the funds are currently frozen, and the deck replacement may not occur until the summer of 1994. The September 30, 1992, Record of Decision requires treatment plant startup by October of 1993. It is not known if deck replacement will be adequate for future loadings.

Final design shall include either replacement of the bridge deck, or bridge replacement, as appropriate. Table TP.05-1 lists minimum county bridge civil engineering design criteria.

Bridge General Plans shall be drawn to scale of at least 1 inch equals 20 feet (1"=20') and shall show General Notes containing a statement as to the criteria for design, either AASHTO Service Load or AASHTO Load Factor. In addition, the design live loads, allowable and design footing pressure, pile design load, and allowable design stresses for reinforced concrete, prestressed concrete, or structural steel shall be shown. A foundation investigation by an engineering geologist or civil engineer may be required by the Shasta County Director of Public Works. Bridge improvement plans shall be approved by the Director of the Department of Public Works prior to commencement of construction.

Existing Private Access Road

The existing private access road to IMM is approximately 7 miles long from the end of the county road, through the mine's main gate, up to Brick Flat Pit. The first mile of roadway from the end of the county road into the mine property is approximately 20 feet to 22 feet wide and is paved. The pavement is in very poor condition with numerous potholes and broken edges. It is structurally inadequate for anticipated heavy loadings. The rest of the main access road is unpaved, varies in width from approximately 20 feet to 24 feet, and contains numerous tight horizontal curves. There is only a jeep trail from the main access road to the possible treatment site location above BFP.

Regardless of the final plant site location, the access road to the plant shall provide year-round accessibility to the plant site for chemical delivery. Table TP.05-2 summarizes the minimum geometric and structural section design criteria for treatment site access road improvements.

Table TP.05-2
IMM Site/Civil Design Criteria
Treatment Plant Access Roads[a]

Minimum design speed[b]	20 miles per hour
Maximum grade	8 percent[c]
Minimum stopping sight distance	125 feet
K value for crest vertical curves (rounded)	10
K value for sag vertical curves (rounded)	20
Minimum outside turning radius	70 feet recommended, but in no case less than 50 feet
Passing sight distance	800 feet
Minimum paved width	20 feet
Minimum graveled shoulder[d]	2 feet (each side)
Minimum graded shoulder[d]	4 feet (each side)
Cross slope, crowned	-3 percent
Maximum ditch foreslope	2:1 (H:V)
Maximum ditch backslope	Not to exceed maximum required for stability
Minimum earth ditch gradient	0.7 percent
Minimum asphalt concrete thickness[e,f]	0.14 foot
Minimum aggregate base thickness[e]	0.5 foot

[a]Based on AASHTO Design Policy, 1990, for special purpose roads; and Shasta County Development Standards.
[b]Design speed may be decreased where the outside turning radius is less than 70 feet.
[c]Maximum grade may be increased for short distances on paved roads to 12 percent where 8 percent is not possible in mountainous terrain.
[d]Where 2-foot graded shoulders in cuts is not possible in mountainous terrain, the width may be decreased. In no case shall width of traveled way be less than 18 feet.
[e]Final structural section shall be based on wheel loading and frequency and determined by "R" value testing.
[f]Where centerline grade exceeds 8 percent, the required minimum thickness of A.C. shall be increased to 0.17 foot.

Cut sections shall be designed with adequate ditches, culverts, and guardrails. Culvert diameter, type, gauge or class, length, slope, inlet and outlet elevation, station, skew, and minimum cover must be included in design plans. Culverts in the roadway shall be designed to Standard HS20-44 live load and shall have a design life of 25 years. Guardrails shall conform to Caltrans metal beam guardrail (MBGR) standard design.

Regardless of the final treatment site location, the main access road to the plant site shall meet the design criteria presented in this memorandum. If the site is located above BFP (refer to Figure TP.05-1), the access road will have to be designed and paved all the way to the top of the mountain. If the site is located lower on the mountain, the access road shall be designed to these criteria only up to the site location. A less reliable road may be provided to haul dewatered sludge from the sludge beds up to BFP, provided there is adequate space lower on the mountain to provide temporary storage of the sludge when the upper road is impassable. This haul road shall be designed to the same criteria as the main access road, but may be unpaved. The maximum unpaved road grade shall be 8 percent. The base thickness shall be sufficient for anticipated wheel loading and shall be adequately sealed and maintained for year-round haul truck access except during the most inclement weather conditions.

If the plant site location is BFP, a new road replacing the existing jeep trail must be provided. The same design criteria outlined for the main access road apply to this new access road.

Treatment Plant Sitework

Treatment plant sitework and earthwork requirements will depend on the design requirements of the treatment plant layout and hydraulics as well as the site location. Site facility and layout requirements shall be closely coordinated with the treatment plant design. Refer to Technical Memorandum TP.03.

Aside from requirements dictated by site location and facility design, roadway access on the site shall include 70-foot minimum turning radii for chemical truck access. The structural section of the site paving and roads shall meet minimum civil design criteria presented for the access roads. Design shall seek to minimize excess earthwork quantities.

If required due to the site location, the site layout may include dewatering facilities for the HDS produced in the treatment of the AMD. These facilities shall be accessible for transport of the sludge onto haul trucks for delivery to a landfill constructed in BFP.

Complete engineering calculations for each drainage basin shall be provided in the final civil design. Stream flow rates and runoff volumes shall be calculated, and the required drainage facilities shall be designed using accepted engineering practices. If surface water is discharged from the project's boundaries and the location or method of discharge has been changed, or where the rate of discharge has been increased, the design engineer shall investigate the impact of such on the downstream property. This investigation shall include all properties affected through to the point where the surface waters collect into a defined water course. If the engineer determines that the proposed change in surface-water runoff has the potential to do damage or that the downstream facilities are not adequate to handle the runoff, the design plans shall include the work necessary to mitigate the impact of the change. If the engineer determines there is no potential for downstream damage and/or the downstream facilities are adequate, a statement of such shall appear on the design plans.

Geotechnical Considerations

Geotechnical investigations should be conducted to evaluate and mitigate possible impacts to existing or proposed facilities from landsliding or slope failure, settlement, subsidence, lateral earth pressures, or seismic accelerations. Site-specific explorations should be conducted at the plantsite, pump stations, bridges, retaining walls, or other structures. These explorations shall consist of field reconnaissance, subsurface exploration, soil sampling, laboratory testing, and analysis, as appropriate.

The geotechnical investigation shall demonstrate adequate factors of safety with respect to slope failure, bearing capacity, settlement, subsidence, or seismic accelerations, or shall provide recommendations for designs to achieve adequate factors of safety for all critical facilities, including the plantsite, pump stations, pipelines, utilities, and access roads.

In particular, should the treatment plant be located adjacent to Brick Flat Pit, thorough geotechnical investigations shall be completed to evaluate the long-term stability of the adjacent pit wall and to provide recommendations for minimum setback of facilities from the crest of the pit wall slope. Slope stabilizing measures shall be provided, if necessary. Likewise, access road construction to this plantsite shall be designed for long-term stability with respect to slope failure. All improvements shall be protected from subsidence or other effects caused by historic mine workings in this vicinity, including underground workings.

The geotechnical investigation shall also include chemical evaluation of existing materials at the treatment plant site and other work areas for potential hazardous or toxic materials. If hazardous or toxic materials are encountered that would provide possible contaminant exposure pathways for workers or operators, recommendations for removal and disposal or other engineering controls shall be provided.

ATTACHMENT J

MONITORING AND REPORTING REQUIREMENTS

PREPARED BY: Linda Mohr/Redding
Carole Crowe/Redding
Jim Stefanoff/Redding

DATE: November 3, 1992

SUBJECT: Monitoring and Reporting Requirements
Treatment Plant for the Boulder Creek OU
Iron Mountain Mine

PROJECT: RDD69017.TP.06

Introduction

This memorandum presents potential monitoring and reporting criteria for the operation of the acid mine drainage (AMD) treatment and sludge disposal facilities at the Iron Mountain Mine (IMM) project site. The treatment facilities will be designed and operated to chemically neutralize and precipitate heavy metals from the Richmond and Lawson portal AMD flows. Brick Flat Pit will be modified for disposal of process sludge and collection of filtrate from the pit. The parameters for monitoring the treatment performance and effluent quality will likely be based on compliance standards and discharge limitations as described below.

Compliance Standards

In the September 30, 1992, Record of Decision (ROD) for the Boulder Creek Operable Unit (OU), EPA addressed the Applicable or Relevant and Appropriate Requirements (ARARs) for the treatment plant effluent. These ARARs specify that the AMD neutralization facility shall be designed and operated to meet the Clean Water Act—Effluent Guidelines and Standards for Ore Mining and Dressing at 40 CFR §440.102(a) and §440.103(a). The ROD specifies that if the effluent is discharged into Boulder Creek or Slickrock Creek, the discharge will need to comply with the effluent limitations of §440.102(a) and §440.103(a), except for pH and total suspended solids (TSS) levels. As stated in the ROD, EPA has determined that for discharges to these two creeks it will not be necessary to adjust the effluent pH (approximate pH 8.5) because of the acidic nature and buffering capacity in these creeks. Treatment to TSS levels prescribed in the Clean Water Act would not be currently necessary due to the high levels of TSS already in the creeks. However, if the discharge from the treatment plant is to Flat Creek, which is not as acidic and does not have high levels of TSS, the pH and TSS standards would need to be met.

Treatment Plant Discharge Permitting

Clean Water Act controls are imposed through National Pollutant Discharge Elimination System (NPDES) permits on a case by case basis. Because the discharges from IMM occur onsite, an NPDES permit may not be required. However, according to EPA, the operation of the treatment plant will certainly include monitoring and reporting criteria that will meet the substantive requirements of such a discharge permit. Therefore, even though no permit is required, Respondents should file documents equivalent to an NPDES permit application and Report of Waste Discharge should be filed with the California Regional Water Quality Control Board (RWQCB).

As the potential enforcing agency, the RWQCB has jurisdiction of the NPDES permitting application and approval process, and for minimum reporting and monitoring requirements. The report and permit application should include a description of the discharge location(s), a process flow schematic of the treatment plant, estimated average and maximum discharges, and average and maximum discharge loads of regulated constituents (e.g., copper, cadmium, and zinc).

The discharge limitations that will probably be outlined in the permit are listed in Table TP.06-1.

Table TP.06-1
Effluent Limitation Summary[a]

Effluent Characteristics	Daily Maximum[b] (mg/l)	30-Day Average[c] (mg/l)
Copper	0.30	0.15
Cadmium	0.10	0.05
Zinc	1.5	0.75
Lead	0.6	0.3
Mercury	0.002	0.001
TSS	30	20
pH	6.0 - 9.0	6.0 - 9.0

[a]Effluent limitations from §440.102(a) and §440.103(a)
[b]Maximum allowable for any one day
[c]Average of daily values for 30 consecutive days

Reporting Requirements

AMD Collection and Conveyance

The following monitoring parameters and reporting frequencies are anticipated for AMD collection and conveyance facilities:

- Flow measurements at the Richmond and Lawson portals (continuous measurements, monthly reporting)

- Water quality at the Richmond and Lawson portals (weekly samples, monthly reporting)

Treatment Plant

The discharge permit for the treatment plant will stipulate the detailed monitoring and reporting requirements. The monitoring requirements will likely include continuously monitored influent and effluent flows, and automated composite sampling with daily testing for pH and metals as listed in Table TP.06-2. While daily testing would probably be required, monthly reporting will likely be appropriate.

Table TP.06-2
Proposed Monitoring Requirements for AMD Treatment Plant

Parameter	Unit	Sample Location		Sampling Frequency
		Influent	Effluent	
Copper	mg/l	✓	✓	Daily
Cadmium	mg/l	✓	✓	Daily
Lead	mg/l	✓	✓	Daily
Zinc	mg/l	✓	✓	Daily
pH	pH units	✓	✓	Daily
Flow	gpm	✓	✓	Continuous

Sludge Handling and Disposal

The following monitoring parameters and reporting frequencies are anticipated for sludge handling and disposal facilities:

- Sludge influent flow rate to ponds or impoundments other than Brick Flat Pit (continuous measurement, monthly reporting)

- Filtrate flow rate from ponds, impoundments, and Brick Flat Pit (continuous measurement, monthly reporting)

- Filtrate water quality from ponds, impoundments, and Brick Flat Pit (automated composite sampling, daily testing, monthly reporting)

- Sludge volume and average percent solids hauled to Brick Flat Pit (daily measurement, monthly reporting)

- Total volume of sludge in Brick Flat Pit and stage/elevation of sludge (monthly measurement and reporting)

- Characteristics of sludge disposed in Brick Flat Pit, TCLP and CalWET tests (monthly measurement and reporting)

Other Monitoring and Reporting

The following monitoring parameters and reporting frequencies are anticipated for this remedial action in the Boulder Creek Operable Unit:

- Rainfall at Brick Flat Pit and at the treatment plant (continuous monitoring, monthly reporting)

- Flow in Boulder Creek at the existing stream gauge (continuous monitoring, monthly reporting)

- Water quality in Boulder Creek at the stream gauge (weekly monitoring, monthly reporting)